JUL 26 1922

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIV.—No. 2950.] *LONDON: FRIDAY, JULY 14, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
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9063
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A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 25 and 29.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 675

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 9048

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 80.

"Spencer-Hopwood" Patent WATER TUBE Boilers. *See page 78.* 677
Sole Makers: SPENCER-BONECOURT, LTD.,
Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 9044

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. **Boilers.**
See page 17. 9047

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9235

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Oct 9753

Electric Cranes.
9063
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.2. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 24, Robertson Street, Glasgow.
See Advertisement page 76, July 7.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS,
SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Oct 3851
ENGINEERS & BOILER MAKERS.

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 9762

OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2932.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Oct 2487
See their Illus. Advertisement, page 93, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS.
MOTHERWELL. Oct 3263

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Oct 3383
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Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9066
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 9063
REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 26, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-HAVVIES, GRABS,
CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and
DECK MACHINERY. 837
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 52. 9053

Economy!
HIGH BOILER EFFICIENCIES
ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS,
HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
25, Broadway, New York, U.S.A. 9060

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 840

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
50, Wellington Street, Glasgow. 9074

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 846

Electric Lifts
(UP TO 35 TONS.)
9063
S. H. HEYWOOD & CO., LTD.
REDDISH.

Hardening & Heat Treatment.
ANY class of tools. H. S. Chasers for adjustable die heads. Case hardening, colouring, etc. We can case harden Cast Iron for gauges, press tools, etc. Write us for particulars, Reliable Work! Right Prices! Delivery to promise!
OWEN & CRISP,
Engineers and Engineers' Agents,
64, Basinghall Street, London, E.C.2.
Telephone:—London Wall 5066. 9050

Diesel Engines, Six Cylinder,
Two and Four stroke, 360, 1000, 1200 H.P., excellent condition. Dynamos for above 250 or 500 volts, D.C. Immediate delivery and low price.
Two 500 Kw. Parsons Turbine Sets, 250 or 500 volts, D.C., with condensing plant and spare armature. Price £2250.
Electrical driven Centrifugal, Ram and other Pumps from 1½ in.–10 in. outlet.
JENNINGS,
West Walls, Newcastle-on-Tyne. 9749

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8738

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 810

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 763
See Full Page Advt., page 56, June 23.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
8198
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers,
Constitution Hill, BIRMINGHAM.
See Full page Advertisement, page 56, June 23.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 56. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 600

GRAPHITED OIL. GRAPHITED WATER.
"OILDAG" (Reg.) BRAND. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE.
"GREDAG" 747
E. G. Acheson Ltd.,
Dept. E., (Sole Manufacturers.) Works:
40, WOOD ST., S.W.1. PLYMOUTH.

Locomotive Traversers
(ELECTRIC).
9063
S. H. HEYWOOD & CO., LTD.,
REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices; 120, Trongate, GLASGOW. Oct 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9737
See half-page Advertisement page 38, July 7.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 898

NOTICE.

Institution of Chemical ENGINEERS.

The First Application Form for Membership and Associate Membership of the above Institution is now being issued. A copy of this Application Form may be obtained from
THE HONORARY SECRETARY,
INSTITUTION OF CHEMICAL ENGINEERS,
166, Piccadilly,
London, W. 1. U 736

The South Wales Institute OF ENGINEERS.

INSTITUTE ENGINEERING EXHIBITION, DRILL HALL, CARDIFF.
NOVEMBER 20TH–25TH, inclusive.

SCHEDULE OF PROPOSED EXHIBITS:—
SECTION 1.
Scientific, Measuring and Recording Instruments, as applied to all branches of Engineering.
SECTION 2. STEAM SECTION.
Water Softening and Cooling Plant.
Boilers and Equipment.
Oil Burners.
Pipes, Valves, Separators, etc.
Drawings of Models of Modern Engines.
Governors and Safety Devices.
SECTION 3. ELECTRICAL SECTION.
Switchgear, Cables, Controllers, etc.
Electrical Tools and other appliances.
Overhead Lines.
Small Motors.
Electric Cranes.
Telephones and Wireless Apparatus.
SECTION 4. MECHANICAL SECTION.
Mechanical Transmission of Power.
Bearings, Clutches, Ropes, Belts, Gearing, etc.
SECTION 5. WORKSHOP APPLIANCES.
Machine Tools (small).
Pneumatic Tools.
Hydraulic Tools.
SECTION 6. MINING AND GENERAL.
Shaft Signalling.
Devices to prevent overwinding.
Models of Pit Cages and Tram Tipplers.
Steel Castings (limited in size and weight).
Models of Coke Ovens, By-Product and Recovery Plant.
Coal Cutting and Conveying Machines.
Pumping Plant.
Models of Screening Plant.

As far as practicable, exhibits will be arranged in their various Sections, but exhibitors will be allowed, when exhibiting under more than one Section, to group their exhibits on one stand.
The Exhibition will be opened each day at Two p.m. and remain open until Eight p.m.
In connection with the Exhibition a Conference will be held each morning at the Institution, Park Place, Cardiff, at which Papers on Engineering subjects will be read and discussed.
Last date for receiving applications for space is July 31st.
Entry Forms, Ground Plan of Exhibition and full particulars may be had on application to:—
THE SECRETARY,
The South Wales Institute of Engineers,
Park Place, Cardiff. U 734

University College of SWANSEA.

(A Constituent College of the University of Wales).

APPLIED SCIENCE DEPARTMENTS.

ENGINEERING.
Professor:—FREDERIC BACON, M.A. (Cantab.), A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.
Lecturer in Electrical Engineering:—R. G. ISAACS, B.Sc. (Lond.), A.M.I.E.E.
Lecturer in Civil Engineering:—To be appointed.
Demonstrator:—J. SELWYN CASWELL.

METALLURGY.
Professor:—C. A. EDWARDS, D.Sc. (Manchester).
Lecturer:—H. I. COX, M.Sc. (Wales & Birmingham).
Assistant Lecturers:—A. L. NORBURY, M.Sc. (Manchester), L. B. PFEIL, B.Sc., A.R.S.M.

The College offers a number of exceptional advantages to Students who aim at entering upon professional careers in Engineering or in Metallurgy. It is situated in the heart of an industrial area, which includes a large number of Works of very varied character, and presents an unrivalled variety of metallurgical practice. The manufacturers of the district, who contribute largely to the support of the College, give the staff and students of the Applied Science Departments every access to the Works, and the Managers, Engineers, and Technical Officials co-operate with the Staff of the College in making visits to Works of practical educational value to the students.
Courses of study are provided (1) for the B.Sc. Degree of the University of Wales in (a) Civil Engineering; (b) Mechanical Engineering; (c) Electrical Engineering; (d) Metallurgy, and (2) for Diplomas of the College in (a) Civil Engineering; (b) Mechanical Engineering; (c) Electrical Engineering; (d) Metallurgy.
Persons who are not desirous of studying for Degrees or Diplomas may attend selected College Classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.
Entrance Scholarships will be offered for competition in September, 1922.
Particulars concerning admission to the College, and of the Entrance Scholarships, may be obtained from the undersigned.
EDWIN DREW,
University College, Registrar.
Singleton Park,
Swansea. U 711

University of Liverpool.

FACULTY OF ENGINEERING.
Dean:—Professor T. B. ABELL, O.B.E., M.Eng., R.C.N.C Ret., M.Inst. N.A.
Prospectus containing full particulars of the following may be obtained on application to the REGISTRAR:—Engineering, Electrical Engineering, Civil Engineering, Naval Architecture, Metallurgy, Geology, Marine Engineering, Design and Drawing, Refrigeration, Mathematics, Physics, Chemistry. T 358

Correspondence Courses for

Inst. Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by MR. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive Individual Tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 56, SOUTH JOHN STREET, LIVERPOOL. 576

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 745

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 748, Offices of ENGINEERING.

Bridge Stresses. — A Civil

Engineer gives Instruction by Post in the Computation of Stresses and Design of Steel and Wooden Structures.—Address, U 752, Offices of ENGINEERING.

TENDERS.

BOROUGH OF CAMBERWELL.

TO ENGINEERS, BOILER MAKERS, ETC.

The Council invite

Tenders for One New Water

TUBE STEAM BOILER and TWO NEW HORIZONTAL STEAM CALORIFIERS, in connection with the re-arrangement of the Boiler House at the Public Baths, Church Street, Camberwell, S.E. 5.
Specification and Form of Tender can be obtained from Mr. FREDERICK J. SLATER, Borough Engineer, Town Hall, Camberwell, S.E. 5.
Tenders, together with complete drawings and full particulars, must be delivered on or before Wednesday, 26th July, 1922, not later than Five p.m. U 739

C. WILLIAM TAGG,
Town Clerk.

THE ASSAM-BENGAL RAILWAY COMPANY LIMITED is prepared to receive

Tenders for:—

(1) 25 BOGIE RAIL and TIMBER TRUCKS.
(2) 100 PAIRS of WHEELS and AXLES.
Specifications and Tender Forms may be obtained at the Offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C. 2. A fee of £1 1s. is charged for each Specification, which cannot under any circumstances be returned.
Drawings may be had at the cost of the Tenderer, by application to Messrs. HODGES, BENNETT & Co., Ltd., 78, Queen Victoria Street, E.C. 4.
Tenders must be delivered at the Company's Offices not later than Noon on Friday, the 28th July, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
OSWALD I. MILNE,
Secretary.
7th July, 1922. U 722

SOUTH AFRICAN RAILWAYS AND HARBOURS.

ELECTRIFICATION OF GLENCOE—PIETERMARITZBURG SECTION.

Tenders are Invited for the

SUPPLY and ERECTION in South Africa of the following PLANT in connection with the electrification of the above Railways, as follows:—
TENDER D. 1417—COAL HANDLING PLANT for Power Station.
TENDER D. 1418—ASH HANDLING PLANT for Power Station.
TENDER D. 1430—CIRCULATING WATER SCREENING PLANT for Power Station.
Separate Specifications and blue prints and Forms of Tender for each of the above sections may be obtained at:—
The Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, W.C. 2, and the Office of the Chief Railway Storekeeper, Park Station Chambers, Johannesburg, on and after Friday, the 28th July, 1922.
The Consulting Engineers, to whom application for any further technical information may be made, are Messrs. MERZ AND MCLELLAN, 39, Victoria Street, London, S.W. 1.
Contractors may tender for all or any of the above sections.
The charge for each Specification is Five Guineas for the first copy and Two Guineas each for any further copies. Sums paid for any number of each Specification up to three will be refunded on receipt of *bona fide* Tenders.
Sums paid for copies of Specifications beyond three of each will not be refunded.
Sealed Tenders marked "Tender No. D. 1417" (or as the case may be) are to be addressed to THE SECRETARY, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, W.C. 2, and lodged in duplicate at his Office in London, not later than NOON, on WEDNESDAY, the 16th October, 1922.
The Administration does not bind itself to accept the lowest or any Tender. U 686

ROHILKUND AND KUMAON RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

(a) 100 COVERED GOODS WAGONS.
(b) 300 pairs of WHEELS and AXLES,
as per specifications to be seen at the Company's offices.
Tenders addressed to the undersigned, and marked "Tender for Goods Wagons," or as the case may be, are to be lodged not later than Noon on Friday, the 4th day of August, 1922.
For each specification a fee of 10/- will be charged, which cannot, under any circumstances, be returned.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
E. A. NEVILLE,
Secretary.
237, Gresham House,
Old Broad Street,
London, E.C. 2.
5th July, 1922. U 714

COUNTY BOROUGH OF BOURNEMOUTH.
(AMENDED ADVERTISEMENT.)

Tenders are Invited for New

DECK JOISTS, DECKING, etc., required on the Bournemouth Pier.
Form of Tender, Conditions, Specification and Bill of Quantities, can be obtained of the Borough Engineer, Mr. F. P. DOLAMORE, at whose office the drawings can be seen, on or after Monday morning, the 10th July, 1922, provided the sum of £1 1s. has been previously deposited in respect of each Tender with the undersigned, which deposit shall become forfeited unless a Tender complying with the conditions be sent in.
Sealed Tenders are to be forwarded in special envelopes which will be furnished for the purpose, to the Town Clerk, Town Hall, Bournemouth, not later than Noon on Saturday, 2nd September, 1922.
The Council do not bind themselves to accept the lowest or any Tender.
F. P. DOLAMORE, F.S.I.,
Borough Engineer & Surveyor.
Town Hall,
Bournemouth.
4th July, 1922. U 733

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification, will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.
SPECIFICATION No. 261:—
STRAIN AND PIN TYPE INSULATORS.
CHARGE:—
£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawing complete. These charges will be returned on receipt of a *bona fide* tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each.
PRELIMINARY DEPOSIT:—
A Preliminary Deposit of £100 is to be lodged with Tender.
The Specifications may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than Noon, 16th September, 1922:—
R. LIDDELOW, Secretary,
STATE ELECTRICITY COMMISSION OF VICTORIA,
MELBOURNE,
Victoria, Australia. U 574

CITY OF SHEFFIELD.

ELECTRIC SUPPLY DEPARTMENT.

CONTRACT No. E.M. 53.

The Electric Supply Committee of the City of Sheffield are prepared to receive

Tenders for the Supply,

DELIVERY and ERECTION of an ASH-HANDLING AERIAL ROPEWAY, complete with all Standards, Guy Ropes, Bridges over Midland Railway, Protective Bridges or Protective Netting over two Roads—the Bridges and Netting should be carried out in accordance with the requirements of the Midland Railway Company and the Corporation of the Borough of Rotherham respectively—also all Hauling and Carrying Ropes, Carriers, Carrier Boxes, Trippers and Reinforced Concrete Loading Station, all in accordance with the Specification and Drawing. The Ropeway shall be of the Double Rope system—Single Rope systems will not be considered.
Contractors desiring to submit Tenders may obtain the Drawings, Specification, Form of Tender and Conditions of Contract at these Offices, on payment of a sum of £5 5s., which sum will be refunded on receipt of a *bona-fide* Tender, or if the documents are returned within four days after receipt, in the event of the Contractor's inability to submit a Tender.
Any person or firm sending in a Tender will be required to add a schedule to such Tender, stating the names of the various classes of labour which he or they intend to employ, together with the place where such labour will be employed, and the rates of wages, hours of labour and conditions of employment to be paid and observed in respect of each class of labour, all of which as shown in such schedule shall comply with the City Council's form of clauses respecting wages, hours and conditions of labour, and prohibition against assigning and sub-letting.
Tenders, which must be made out on the official Tender Form, to be delivered at these offices (enclosed in the official envelope provided) not later than Ten o'clock, on Friday Morning, 28th July, 1922.
The Committee do not bind themselves to accept the lowest or any Tender.
S. R. PHIDDEN, M.Inst.C.E.,
M.I.M.M., M.Inst.E.E.,
General Manager and Engineer.
Commercial Street,
Sheffield. U 716

WEST HAM UNION.

TO LAUNDRY ENGINEERS.

The Guardians Purpose

having carried out certain ALTERATIONS, involving the SUPPLY of NEW MACHINERY, the Removal and Refixing of Existing Machinery, and the necessary Services and Shafting, to the Main Laundry at their Central Home, Union Road, Leytonstone, E. 11, at an approximate cost of £5000.
Persons and Firms desirous of Tendering for the Work should forward to the undersigned their names and addresses together with a deposit of £2 2s., which will be returned upon receipt of a *bona fide* Tender. A copy of the Drawing and Specification prepared by the Architect of the Guardians, Mr. F. J. STURDY, of 116, Moorgate, E.C. 2, will be sent in exchange.
Tenders must be delivered to the undersigned not later than Ten a.m., on Thursday, the 27th July, 1922.
By Order of the Board,
THOMAS SMITH,
Clerk to the Guardians.
Board Room, Union Road,
Leytonstone, E. 11.
10th July, 1922. U 750

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Borough Council invite

Offers for the Purchase of:—

(i) 2000 Kw. Vertical type Curtis TURBO-ALTERNATOR, by Messrs. The British Thomson-Houston Co., Ltd.
(ii) SURFACE CONDENSING PLANT, by Messrs. The British Thomson-Houston Co., Ltd. Capacity 27,000 lb. per hour.
(iii) CONTRA-FLOW CONDENSING PLANT, by Messrs. Richardsons, Westgarth & Co., Ltd. Capacity 40,000 lb. per hour.
Specification and full particulars obtainable from the Engineer and Manager, Electricity Department, 88, Fulham Palace Road, W. 6.
Offers must be submitted to the Engineer and Manager, properly endorsed, not later than Four p.m., on Friday, 21st July, 1922.
LESLIE GORDON,
Town Clerk.
Town Hall,
Hammersmith, W. 6.
13th July, 1922. U 754

BOMBAY, BARODA & CENTRAL INDIAN RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 2nd August,

Tenders for the Supply of—

1. METALS.
2. BOLTS, NUTS and RIVETS.
3. DOG SPIKES.
4. WIRE GAUZE and NETTING.
5. WOOD SCREWS, NAILS, SPLIT PINS, etc.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment of 20s. each for Nos. 1 and 2, and 10s. each for Nos. 3, 4, and 5 (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
(Signed) S. G. S. YOUNG.
Secretary.
Offices:—The White Mansion,
91, Petty France,
Westminster, S.W. 1.
10th July, 1922. U 740

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of:—

1. ROLLING STOCK (270 Steel Ballast Wagons and Nine Brake Vans).
2. STEEL TYRES (363 Locomotive, and 3000 Carriage and Wagon).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Rolling Stock," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 4th August, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of £1 for each copy of Specifications Nos. 1 and 2.
Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1,
13th July, 1922. U 745

LONDON COUNTY COUNCIL.

Tenders are Invited for the

PURCHASE and REMOVAL of the undermentioned PLANT:—
SIX WATER TUBE BOILERS of the Stirling five-drum type, each fitted with superheated and two chain grate stokers. Each boiler has a rated output of about 14,000 lbs. of water evaporated an hour from and at 212 F.
THREE GREEN'S ECONOMISERS, each fitted with scraper gear and having a heating surface of 3,300 square feet.
The Plant may be inspected at the Council's Tramway Power Station, Hoskins Street, East Greenwich, between the hours of Nine a.m. and Five p.m. on any week-day, except Saturday, from 17th to 31st July, 1922, both dates inclusive, upon production of the Tender Form.
Particulars and Forms of Tender may be obtained on application personally or by letter to the General Manager, London County Council Tramways, 23, Belvedere Road, Lambeth, S.E. 1.
Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Westminster Bridge, S.E. 1, not later than Twelve noon on Tuesday, 1st August, 1922. No Tender received after that time will be considered. The Council does not bind itself to accept the highest or any Tender.
JAMES BIRD, U 748
Clerk of the London County Council.

55,000-H.P. TURBINES FOR THE QUEENSTON POWER STATION, ONTARIO.

WE have on previous occasions referred to the important scheme known as the Queenston-Chippawa Development of the Hydro-Electric Commission of Ontario, and now well on the way to completion.*

As a matter of fact the first of the large turbine units of this plant was put into operation on December 28 last year. Recently, at a convention organised in Philadelphia, Pa., U.S.A., by the Engineers' Club, Mr. Frank H. Rogers, hydraulic engineer of the I.P. Morris Department of the William Cramp and Sons Ship and Engine Building Company, read a paper describing the large turbines his firm had supplied for this plant, and through the courtesy of Mr. Rogers we are now able to give the following account and illustrations of these turbines.

When, in 1919, the Niagara Falls Power Company installed in their new station three hydraulic turbines, each of 37,500 h.p., these turbines were the most powerful units built up till that time, and they maintained that record until December 28, 1921, on which date the Queenston-Chippawa plant of the Hydro-Electric Power Commission of Ontario was officially opened, and the first 55,000-h.p. turbine started in operation as stated above. These turbines are now the most powerful units in the world by a margin of nearly 50 per cent.

The power house is located near Queenston on the Canadian side of the Niagara River, about 4 miles below the Canadian falls. The intake is located near Chippawa, about 2½ miles above the falls. From the intake the water flows through a portion of the Welland River and through a power canal, 8 miles long, to the forebay, where the elevation of the water is about 308 ft. above the water level in the river below. It is understood that the final installation will consist of nine units having a total capacity of between 550,000 h.p. and 650,000 h.p. The present installation consists of five 55,000-h.p. units, two of the generators being furnished by the Canadian General Electric Company, three of the generators by the Canadian Westinghouse Company, two of the turbines by the Wellman-Seaver-Morgan Company, the five main Johnson valves by the Larner-Johnson Valve and Engineering Company, and three of the turbines and the five governing mechanisms by the I. P. Morris Department of the William Cramp and Sons Ship and Engine Building Company.

Fig. 1 shows the general lay-out of the screen house, penstock and power-house. The penstock for each unit is about 400 ft. in length, the upper two-thirds of the penstock being 16 ft. in diameter and the lower third 14 ft. in diameter. The lower end of the penstock is connected to a 14-ft. by 10-ft. Johnson valve, which is in turn connected to the turbine casing by cast steel piping, 10 ft. in diameter. When completed the power-house will have a total overall length of about 675 ft. and the roof will be located about 160 ft. above the river level.

Fig. 2, page 32, shows a vertical section through one I. P. Morris turbine and Johnson valve, and an outside view of the generator. Each turbine is designed to develop 55,000 h.p. under an effective head of 305 ft. at a speed of 187½ r.p.m. The quantity of water required at full load will be about 1,750 cub. ft. per second. Each unit is of the vertical shaft, single-runner type, provided with cast steel runner, cast steel volute casing and Moody spreading draught tube formed in the concrete substructure of the station. The great size of the unit will be appreciated from the following weights:—

The total weight of the generator is 1,380,000 lb., and of the turbine 620,000 lb., giving a total weight for the combined unit of 2,000,000 lb. The thrust bearing supported above the generator is designed to support a total revolving weight plus allowance for hydraulic thrust of nearly 1,000,000 lb. For the first three units Kingsbury bearings were furnished and for the two remaining units, General Electric spring bearings.

Owing to the great size of these units and the high head under which they operate, special construction was required in order to avoid excessive stresses and prevent leakage. Therefore the usual design of volute casing with separate speed ring was not considered the best, and a new type of casing was developed especially for this installation, known as the Taylor sectional spiral casing.

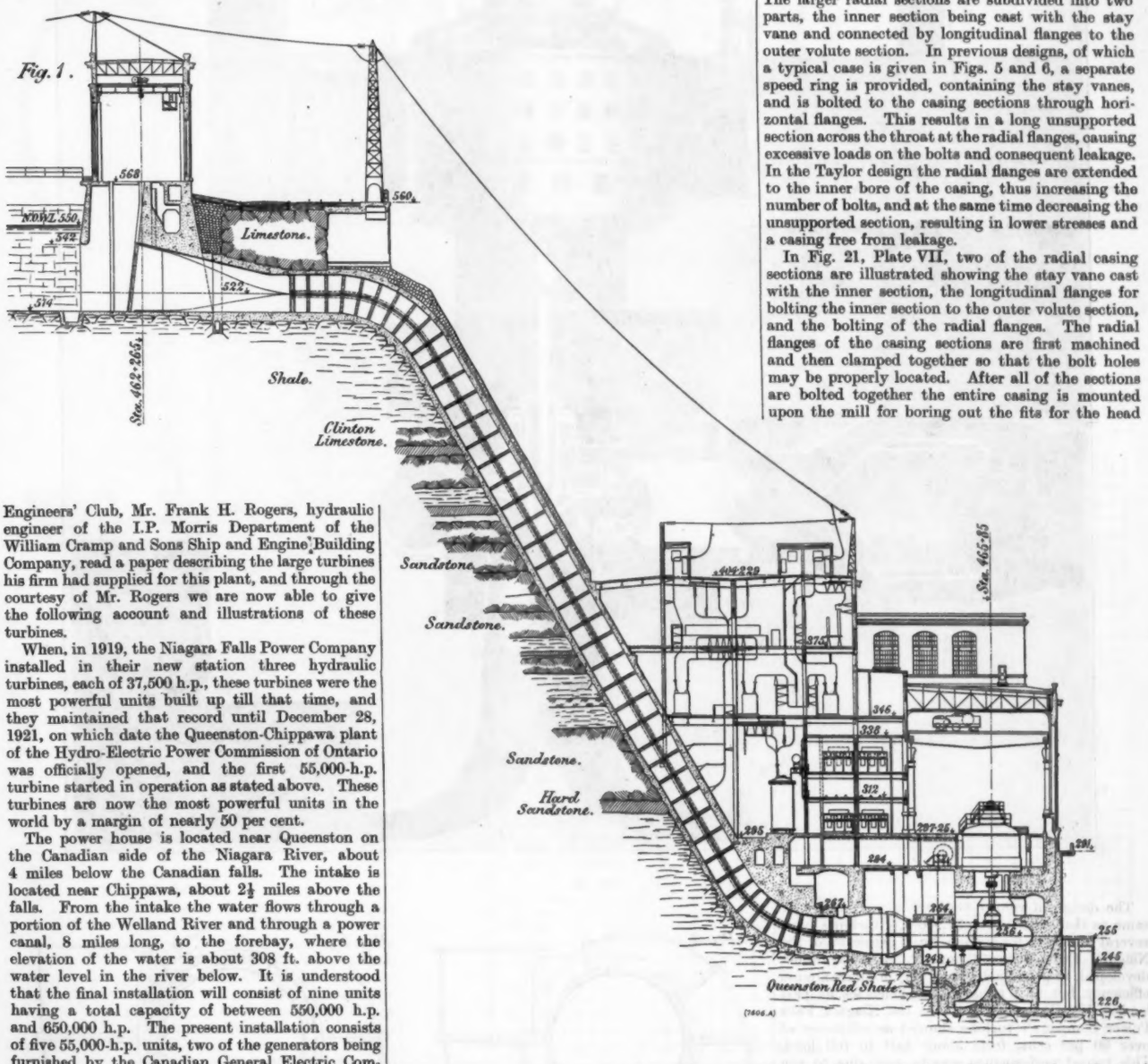
Figs. 3 to 6 show a comparison between one form of this new type of casing and the usual type. It will be noted that in the new design, Figs. 3 and 4, the casing is divided into a number of radial sections. The larger radial sections are subdivided into two parts, the inner section being cast with the stay vane and connected by longitudinal flanges to the outer volute section. In previous designs, of which a typical case is given in Figs. 5 and 6, a separate speed ring is provided, containing the stay vanes, and is bolted to the casing sections through horizontal flanges. This results in a long unsupported section across the throat at the radial flanges, causing excessive loads on the bolts and consequent leakage. In the Taylor design the radial flanges are extended to the inner bore of the casing, thus increasing the number of bolts, and at the same time decreasing the unsupported section, resulting in lower stresses and a casing free from leakage.

In Fig. 21, Plate VII, two of the radial casing sections are illustrated showing the stay vane cast with the inner section, the longitudinal flanges for bolting the inner section to the outer volute section, and the bolting of the radial flanges. The radial flanges of the casing sections are first machined and then clamped together so that the bolt holes may be properly located. After all of the sections are bolted together the entire casing is mounted upon the mill for boring out the fits for the head covers. Each casing is made in 12 sections, the total weight being about 290,000 lb.

A casing was tested in the shop to a hydrostatic pressure of 260 lb. per square inch, this being double the normal operating pressure. When the pressure was applied for the first time in the shop, the casing was found to be absolutely tight against leakage. A special test barrel was inserted in the casing bore. The total load on the head bolted to the casing intake flange during the test was 3,000,000 lb.

In order to develop the highest possible efficiency and to maintain this efficiency for a long period, a number of special features were adopted for the various parts, but under this heading only the runner, guide vanes and draught tube will be described.

Fig. 1.



* See vol. cx, page 734, and vol. cxi., page 127.

55,000-H.P. TURBINE UNITS FOR THE QUEENSTON HYDRO-ELECTRIC PLANT.

CONSTRUCTED BY THE I.P. MORRIS DEPARTMENT OF THE WILLIAM CRAMP AND SONS SHIP AND ENGINE BUILDING CO., PHILADELPHIA.

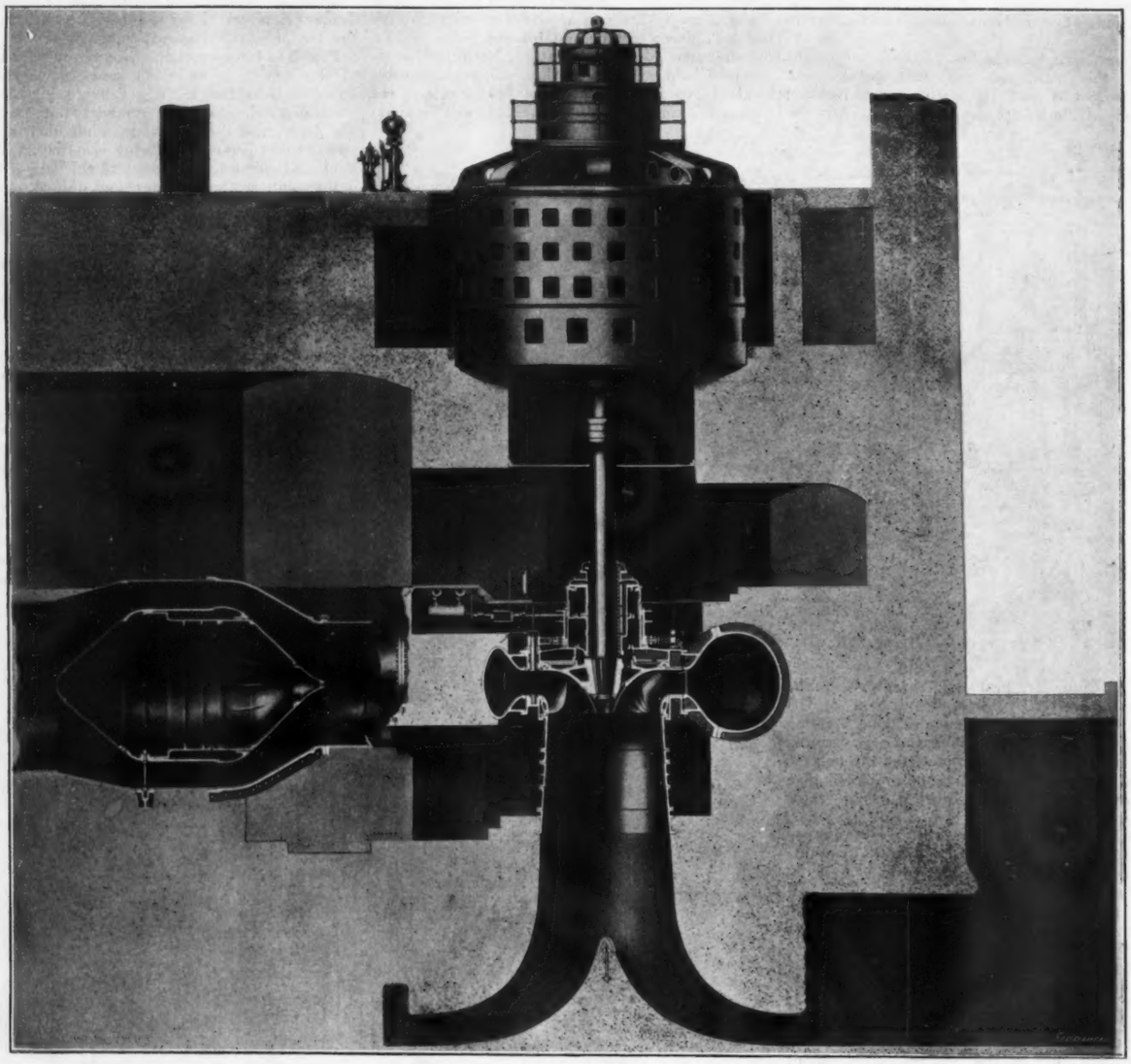


FIG. 2.

The design of runner adopted is practically the same as that used in the 37,500-h.p. turbines built several years ago for station No. 3 extension of the Niagara Falls Power Company, as this runner developed, in place, not only a very high maximum efficiency but also remarkable efficiencies at part loads. It will be recalled that the Niagara Falls Power Company's turbine showed an efficiency of over 90 per cent. from about half to full load. This record performance was in part due to the labyrinth seals adopted for the runner, as shown in Fig. 7, page 33. The leakage water in its path from the discharge of the guide vanes to the draught tube must pass through three separate seals, in each of which the velocity head is entirely lost. Thus the head-producing leakage at each seal is only one-third of the head existing at the discharge of the guide vanes. It is estimated that at full load, the leakage at the seals of this runner amounts to 14 cub. ft. per second, which is only eight-tenths of 1 per cent. of the full load quantity. If this runner had been provided with the usual design of single seal, the leakage would have amounted to about 26 cub. ft. per second, or 1·5 per cent. of full-load quantity. In Fig. 7 is also shown the passage of the leakage

Fig. 3.

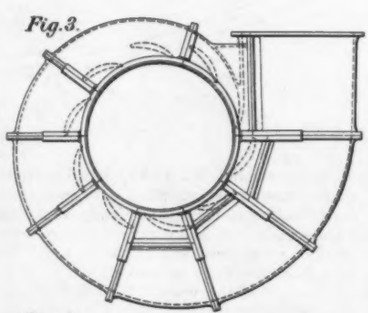


Fig. 5.

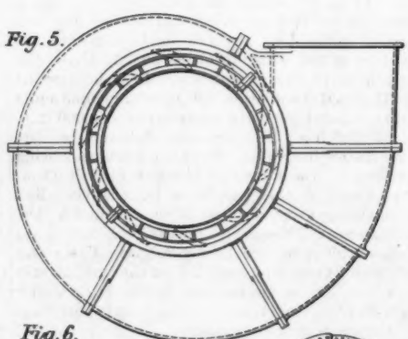


Fig. 4.

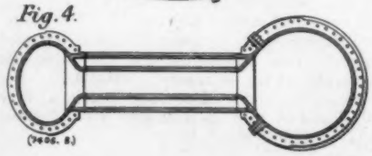
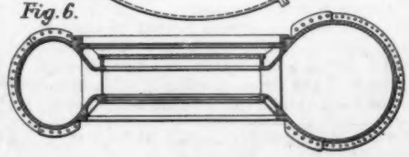


Fig. 6.



water from the upper runner seals through the head cover and vent holes in the runner to the top of the draught tube. This arrangement results in minimum hydraulic thrust on the runner. This method of reducing the leakage not only results in high initial efficiency, but also in the maintenance of this efficiency for a long period of time, for due to the much lower velocity of the leakage water, the wear at the seals will be materially reduced.

company and illustrated in Fig. 8, whereas No. 2 unit is provided with a Moody spreading-tube designed by the Cramp Company, as shown in Fig. 9. As these two units are of exactly the same design throughout, with the exception of the draught tubes, the efficiency tests which will probably be made at an early date, will be of special interest in showing the difference in efficiencies of the two turbines resulting from draught tube design.

speed change for a given load change at all points of operation.

To study the requirements for the 55,000-h.p. turbines, consider the curves shown in Figs. 10 and 11. In Fig. 10, the horse-power delivered is plotted against the efficiency of the turbine and the guide vane opening. The desired piston travel is also plotted as a straight line in order to meet the requirement that a given piston travel produces

Fig. 7.

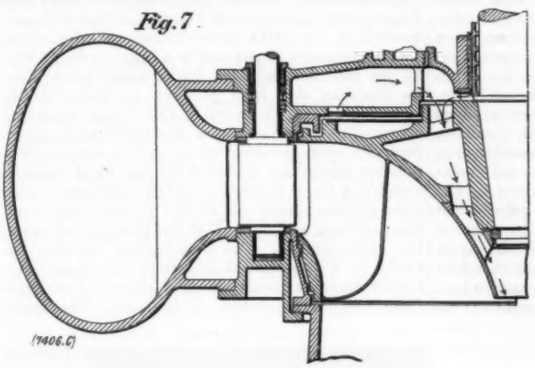


Fig. 8. UNIT No 1 CURVED DRAFT TUBE.

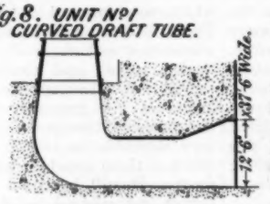
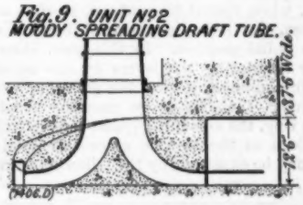


Fig. 9. UNIT No 2 MOODY SPREADING DRAFT TUBE.



GUIDE VANE OPENING AND PISTON TRAVEL REQUIRED FOR UNIFORM SPEED REGULATION.

Fig. 10.

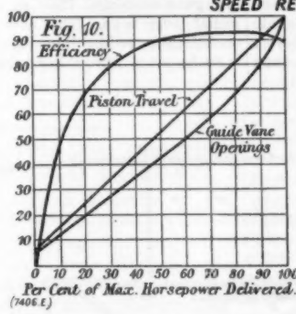


Fig. 11.

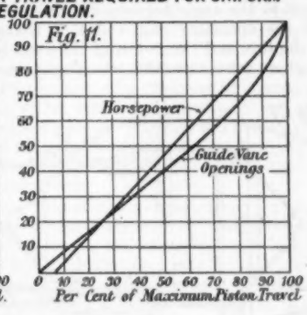


Fig. 12.

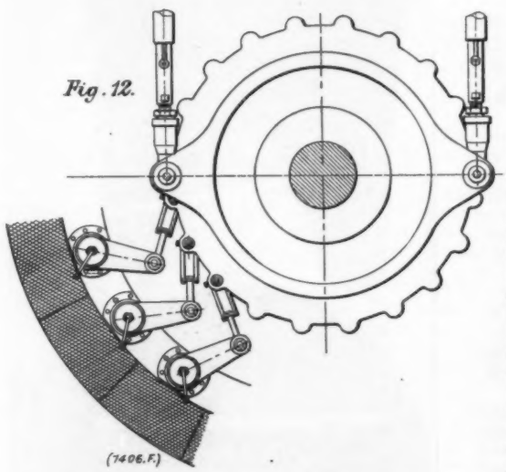


Fig. 17.

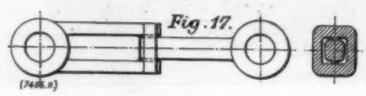


Fig. 13.

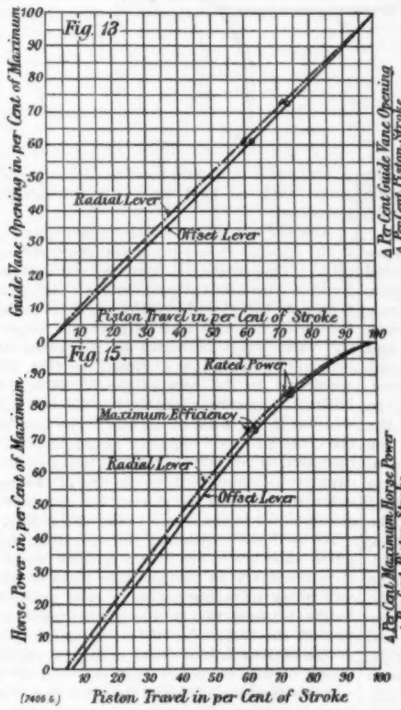


Fig. 14.

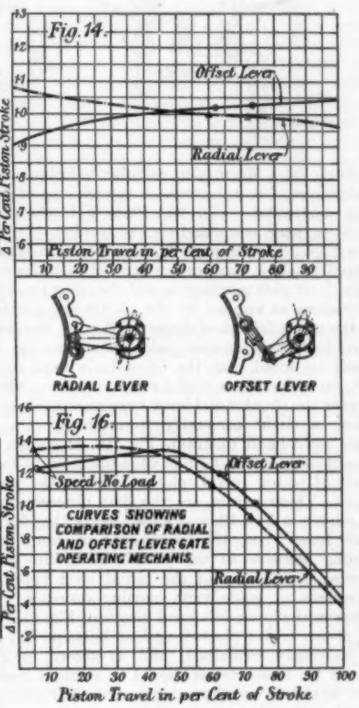


Fig. 15.

Fig. 16.

Speed-No Load
Offset Lever
CURVES SHOWING COMPARISON OF RADIAL AND OFFSET LEVER GATE OPERATING MECHANIS.
Radial Lever
Piston Travel in per Cent of Stroke

The runner is of cast steel, the vanes being cast integrally with the crown and band. The outside diameter of the runner is 10 ft. 4⅞ in., and its weight 42,000 lb. A view of the runner in the shop is given in Fig. 18, Plate VII.

The guide vanes are of the Overn disc type, as illustrated in Fig. 22, Plate VII. Heavy discs are cast between the vane proper and the upper and lower shanks. These discs when in place are flush with the upper and lower distributor plates, so do not interfere with the flow of water through the vanes. The discs reduce the amount of leakage water passing above and below the vanes, and thus guide the water at the proper angle to the runner. This results not only in higher efficiency, but also materially reduces the leakage when the guide vanes are closed. In addition to these points, this type of guide vane results in a very much stronger mechanical connection between the vane and the shanks.

The draught tubes for the three I. P. Morris turbines are of the Moody spreading type, and therefore not only regain efficiently the axial components of the discharge water from the runner, but also regain the whirling components, resulting in high partly open gate efficiencies, and operation of the unit free from the usual vibrations.

In the case of the two turbines furnished by the Wellman-Seaver-Morgan Company, No. 1 unit is provided with a curved tube designed by that

The speed regulation of units of so great a power is of vital importance, and for this reason a special operating gear was adopted. In order to obtain a uniform degree of speed regulation at all points of operation, a given load change on the generator should result in the same speed change irrespective of the initial load on the unit. In turbine governors, the design is usually such that a given speed change always results in the same amount of travel of the piston of the operating cylinder for all positions. If therefore the operating gear of the turbine is designed so that a given piston travel produces the same change in power on the turbine, the desired result is accomplished, namely, the same

the same increment of power. It will be noted that due to the shape of the efficiency curve, the guide vane opening curve is concave from above, the increments of guide vane opening increasing as the horse-power increases, particularly beyond the point of maximum efficiency. The curves shown in Fig. 11 indicate the piston travel plotted directly against the guide vane opening to obtain the desired straight line horse-power curve. To obtain a uniform degree of speed regulation at all points of operation, therefore, the operating gear should be designed to produce a guide vane opening curve with respect to piston travel as shown. For mechanical reasons it is usually impossible to

produce this curve exactly, but the special type of operating gear developed by Mr. F. H. Rogers, approaches quite closely to the desired results. This gearing is known as the "offset lever gate-operating mechanism."

In Fig. 12 is shown a plan drawing of this new operating gear, and it will be noted that the levers attached to the stems of the guide vanes are offset from the usual radial position. To close the turbine gates the operating ring turns in a counter-clockwise direction, when viewed from above, so that as the gates close, the levers are moved further away from the radial position. In this gear, therefore, the links connecting the levers to the operating ring are in compression when the gates are closing. It is evident that for given movements of the operating ring, the amount of guide vane movement will decrease as the turbine gates close and this relation may be expressed by the following formula:

$$\frac{\text{Angular velocity of vanes}}{\text{Angular velocity of operating ring}} = \frac{\sin R}{\sin V}$$

in which R is the angle between the link and the radius of the operating ring, and V is the angle between the link and the radius of the vane lever.

As the guide vanes close this ratio decreases, thus resulting in a decreasing angular velocity of the guide vanes, *i.e.*, a decrease in the amount of guide vane movement. Fig. 23, Plate VII, shows the operating gear assembled on the turbine.

In Figs. 13 to 16, page 33, four sets of curves are plotted to show the comparison between the usual radial lever gate mechanism and the offset lever gate mechanism as applied to the 55,000-h.p. turbines. On the upper left-hand diagram, Fig. 13, the piston travel is plotted against guide vane opening, and it will be noted that the offset lever type results in a curve having a slight concavity from above, whereas the usual radial lever type results in a curve having a slight convexity from above. On the upper right-hand diagram, Fig. 14, is shown the ratio of increments of guide vane openings to increments of piston travel, plotted against the piston travel. These curves are the first differentials of the curves in Fig. 13, and show clearly that for the offset lever type, the increments of guide vane opening increase as the piston opens the gates, whereas in the case of the radial lever type, the increments of guide vane opening decrease. The curves in the lower left-hand diagram, Fig. 15, show the piston travel plotted against horse-power, and as previously explained, and as shown in Figs. 10 and 11, these curves should be straight lines in order to obtain a uniform degree of speed regulation. For the offset lever type, this curve is practically a straight line up to the point of maximum efficiency, whereas the curve for the radial lever type is convex. The first differential of these curves is shown in Fig. 16. For the offset lever type, this curve is very nearly horizontal from no load up to the point of maximum efficiency. Beyond this point the curve falls off rather rapidly. This would indicate that the speed regulation on this particular turbine should be of a uniform degree from no load to the point of maximum efficiency, and would be somewhat impaired beyond maximum efficiency. For the radial lever type, the curve is a maximum at no load and decreases throughout the opening stroke of the piston. Therefore the degree of speed regulation would be best at small loads and would decrease as the piston opens the gates. Although it would be desirable to design the operating gear so as to obtain horizontal lines throughout the entire stroke, it is found from mechanical reasons difficult to obtain this result.

Another point to be considered in the design of the operating gear is the fact that at small gate openings on a turbine, the hydraulic conditions are very poor, resulting in eddies and whirls which cause internal load changes, varying rapidly. These internal load changes have no connection whatsoever with the load changes on the generator. Such internal load changes, however, result in rapidly fluctuating speed changes and hence movements of the governor, which in turn produce movements of the operating piston. It is, therefore, very desirable to reduce as far as possible, the effect of these speed changes on guide vane movements. It will be noted from the curves in the figures just referred to, that with the offset lever type, the guide vane movements are smaller at low gate openings, than in the case of the usual radial lever type. This new gear should therefore considerably reduce hunting of the governor, which is so frequent a trouble at small load conditions on a unit, and it should be of particular value at speed with no load when synchronising the generator.

Another advantage of the new type of gear is the possible reduction in the governor capacity. This value is fixed by the maximum hydraulic load on the guide vanes which always occurs at the closed position. It is evident that with the new type of gear the torque on the vane levers increases as the gates close, becoming a maximum at closed position, where required. In the case of the 55,000-h.p. turbines, the governor capacity is 230,000 ft.-lb., whereas if the usual radial lever type gear were used, the governor capacity would have to be increased to 260,000 ft.-lb. This lower governor capacity not only reduces the size of the operating cylinders but also the size of the governor pumps, accumulator tanks, sump tanks and piping.

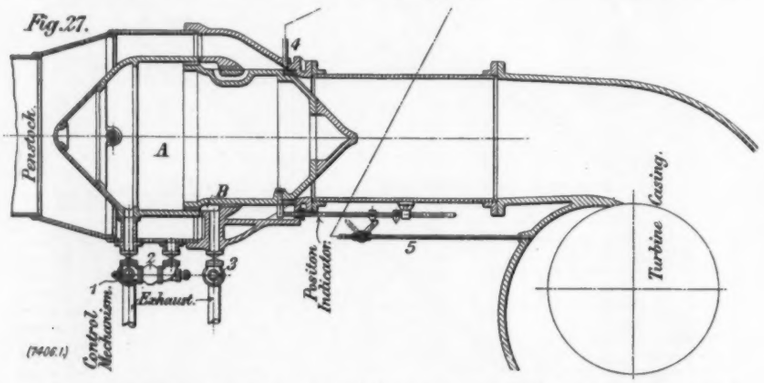
As the links connecting the operating ring to the guide vane levers are in compression when closing, it is necessary to design these links so that they will break in compression, in case an obstruction lodges between two of the guide vanes, and thus protect the remainder of the operating gear. The design of these links is shown in Fig. 17, page 33, from which it will be noted that one end of the link consists of a single bar and the other end of a double bar, the two ends being cast together with a transverse connection, which will break by shearing. These links will also protect the operating gear for opening movements by breaking in shearing, if an obstruction should become lodged between the back of the guide vane and the casing stay vane.

But brief mention can be made of the remaining parts of the turbine. Special precaution was taken in the design of the *lignum vitæ* main guide bearing in order to insure an ample supply of water to this bearing under all conditions. Cored passages are provided on the sides of the bearing so that the lubricating water is admitted not only at the top of the bearing but also at two intermediate points down the bearing. The upper sections of the draught tube are made of cast-iron, the centre section being cast in four pieces, so that this section can be removed when it is desired to dismantle the runner from below without interfering with the generator. One of the assembled turbines is shown well in Fig. 19, Plate VII, while Fig. 24 also gives a very good idea of the size of these units.

The five governors furnished for this plant are of the I. P. Morris double floating-lever type, with Taylor automatic control. The governor actuator and hand control, as shown in Fig. 25 on Plate VII, are located on the main power-house operating deck. These governors, illustrated to a larger scale in Fig. 20, are furnished with the Taylor automatic control for changing over from governor to hand control, or *vice versâ*. To accomplish this result, pressure-operated plunger valves are provided for the pipes from the main governor valve, and similar smaller plunger valves are provided for the hand control stand. A single movement of the lever shown will close simultaneously all of the plunger valves on the governor, and open all of the plunger valves on the hand control. The change over can thus be made in a fraction of a second and positively insures proper sequence of valve operation without danger of losing control of the unit. The main governor valve is located below on the turbine operating deck.

A central pumping system is installed consisting of two motor-driven pumps, each having a capacity of 700 gallons of water per minute, against a pressure of 200 lb. per square inch. Each of these pumps is designed to take care of five main units, the second pump being held as a spare. The motor-driven pumps are supplied from a central concrete sump tank and deliver the water into a common pressure main, which is connected to the accumulator tank at each unit. The return water from each governor is delivered into a common return main which empties into the concrete sump tanks. In this system, water is used as the governor fluid. This water is treated with a small percentage of potassium bichromate to prevent rusting or corroding of the governor valves and piping. This method of treating the water has been successfully adopted in many prominent plants, such as the Cedars Station of the Montreal Light, Heat and Power Consolidated, the plants of the Shawinigan Water and Power Company, and the Nipigon Station of the Hydro-Electric Power Commission. The motors for the governor pumps are of the slip-ring type, and operate continuously, the water not required for the governors being by-passed through

Fig. 27.



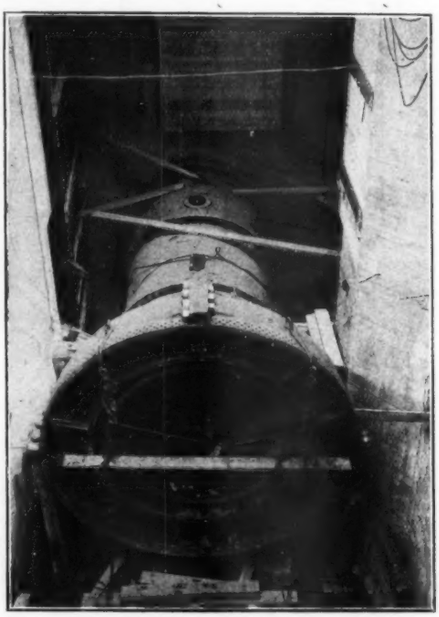


FIG. 28. VALVE BEING ERECTED IN THE POWER STATION.

a needle valve from the pressure main to the return main.

The position of the main Johnson valves is shown in Figs. 1 and 2. These valves are riveted to the lower end of the penstocks and are connected by cast steel piping to the turbine casings. Each of these valves has a 14 ft. intake diameter and a 10 ft. discharge diameter. One of the valves is shown partly completed in the shop in Fig. 26, part of the casing having been left off for the purpose of taking the photograph from which this view is reproduced.

Fig. 27, page 34, is a diagrammatic drawing of the Johnson valve in the closed position. The valve is operated by hydraulic pressure taken from the penstock. Three small piston-operated control valves are furnished, No. 2 admits penstock pressure to the internal chamber A of the plunger, No. 1 exhausts pressure from the internal chamber, and No. 3 exhausts pressure from the annular chamber B. It is not necessary to provide a control valve to admit pressure to the annular chamber, as this chamber is normally under pressure due to the leakage at the fit between the body and plunger. Under normal conditions the control handle is set at neutral, which results in all three of the control valves being closed. To close the Johnson valve the control handle is moved to open the control valves Nos. 2 and 3, thus admitting penstock pressure to the internal chamber A, and exhausting pressure from the annular chamber B. In order to prevent the valve striking the seat with too great a force, a small pipe is provided at the throat of the Johnson valve (4 in Fig. 27) connected to all the control valves, so that a drop in pressure at this point will result in closing the control valves. Therefore when the plunger approaches within about $\frac{1}{8}$ in. of its closed position, the pressure at the throat is reduced, due to the high velocity, and thus automatically closes control valves Nos. 2 and 3. The main plunger can therefore only close the remaining distance at a very slow rate, equal to the time required for the water in the annular chamber to leak into the internal chamber past the fit. This prevents serious hammer when closing the valve.

To open the Johnson valve, the control handle is reversed and opens control valve 1, which exhausts the pressure from the internal chamber of the plunger so that the pressure in the annular chamber will start to open the valve. A slight movement of the main plunger, however, will immediately cause a reduction in pressure at the throat of the valve due to the high velocity and the small pipe 4 connected at this point will immediately close exhaust valve 1, thus restoring pressure in the internal chamber and returning the plunger to the closed position. This action immediately restores the pressure at the throat and again opens exhaust valve 1. Therefore the main plunger will continue to oscillate back and forth through a very short stroke until the turbine casing is primed, after which the plunger will continue to open for its entire stroke.

The Johnson valve is also designed for automatic closing in case of an accident, such as a break in the turbine casing. This is accomplished by providing a pipe connection between a point on the volute casing of the turbine (5 in Fig. 27) and control valves Nos. 2 and 3, such that a large reduction in pressure at the turbine casing will cause these control valves to open and thus close the Johnson valve in the same manner as by the manual control. Fig. 28 shows the body and front of the plunger being erected in the power-house.

Due to the great amount of power developed in each unit, it is of vital importance that the operator should have complete knowledge of all of the operating conditions and positive control of the unit at all times. To accomplish these results, a special control stand was built by the Cramp Company from designs suggested by Mr. H. G. Acres, chief hydraulic engineer of the Hydro-Electric Power Commission of Ontario. This control stand is located on the main generator-operating deck, and may be seen in Fig. 25, Plate VII. It contains gauges showing the operating conditions of the main turbine and principal auxiliaries, namely, gate-opening indicator, pressure on governor system, flow meter for *lignum vitæ* bearing, turbine casing pressure, draught tube vacuum, air pressure for brakes, electrical meters and telegraph and telephone communicating with the main control room.

In Fig. 25 is shown the relative location of the control stand, generator and turbine governor. The tachometer for indicating the speed of the unit is located on the governor stand. On the governor stand are also located the necessary controls for starting the turbine, adjusting load, shutting down the unit or changing over to hand control, whereas on the control stand are located the air control for the brakes and a control lever for shutting down the main Johnson valve. It is therefore seen that a single operator from one position can readily observe the performance of the unit and principal auxiliaries, and can also start up the unit, adjust the load, change over to hand control or shut down as required in regular operation, and in case of an emergency, can also close the main Johnson valve if the turbine gates should become blocked.

In conclusion it should be stated that in the design of these units, draught tubes and water passages, the manufacturers were given the fullest co-operation of the engineers of the Commission, with the object in view of obtaining the best possible results in mechanical operation, control, speed regulation and efficiency developed.

CHOICE OF A SYSTEM FOR ELECTRIC TRACTION ON MAIN LINE RAILWAYS.

By L. THORMANN, Consulting Engineer to the Bernese Subsidised Railways.

(*Continued from page* 3.)

Efficiencies of the Systems.—The economy of a system depends on the loss in energy from the generator shaft to the driving axle. The efficiency of the whole transmission comprises the efficiencies of the several parts, and it is the average conditions which have to be considered. It is obviously impossible to give figures for all cases to which no possible objection can be taken, and estimates will have to be accepted because different conditions exist in different places. Nevertheless the assumptions permit conclusions to be drawn on the economy of the systems. The ratio of the maximum peak load to the average load is of particular importance. In what follows the three-phase system will not be further considered, as important extensions of this system are unlikely.

In the annexed table comparative figures are given for continuous-current traction with three-phase generation, for single-phase traction with single-phase generation and for single-phase traction with three-phase generation. Motor generators are assumed for the conversion from three-phase into single-phase and also into continuous current, because up to the present neither rotary converters nor mercury rectifiers are available for 3,000-volt continuous current. The efficiency of conversion for continuous-current traction, including that of transformation for the transmission pressure, has been taken somewhat lower than for the single-phase case, because the lower voltage of the former renders it suitable for serving a smaller area—thus making the utilisation worse and increasing the no-load loss correspondingly. For the same reason, the loss in the overhead conductors are in general larger for continuous than for single-phase current, because with the latter system it is not the transmission losses as a rule which fix the dimensions of the overhead conductors and the distance between feeding points, as will be shown later. On the other hand, the efficiency of the continuous-current locomotive has been placed higher. The efficiency figures for the single-phase system are taken from a series of trials on the Loetschberg Railway, specially carried out for this purpose.

For transmission the same value has been taken for single-phase as for three-phase—an assumption which will be presently justified. These figures show that the losses are greatly increased by conversion and become about 20 per cent. higher than with direct generation of single-phase current for the overhead system. This may be very important under certain conditions, as for example, with a water-power station, where the available power is limited. Unnecessary losses ought to be always avoided, even though they may appear to be justified on grounds of economy. With the technical means now available, the utilizable sources of energy in Nature are not inexhaustible—whether water powers or coal supplies.

Average Efficiency from Generator Shaft to Wheel Rim of Locomotive.

——	Continuous Current at 3,000 Volts produced from Three-Phase.	Single-Phase Current at 15,000 Volts produced	
		Direct.	From Three-Phase.
Locomotive	0·80 } 0·72	0·76 } 0·70	0·76 } 0·70
Overhead conductors	0·90 }	0·92 }	0·92 }
Motor generator ..	0·78	—	0·80
Double transformation	0·90	0·91	0·91
Transmission	0·94	0·94	0·94
Total	0·475	0·60	0·48

The above figures can also be obtained with regenerative braking in both systems, which is now practicable. If the motor generators used for converting three-phase into continuous current can eventually be replaced by rotary converters or mercury rectifiers, the efficiency of conversion will become about 0·91 for the converter and 0·98 for the rectifier, thereby bringing the overall efficiency of the continuous-current system into agreement with that of the single-phase system with single-phase generation.

Energy Distribution.—Apart from the disadvantages of a lower efficiency of distribution, those systems in which the energy is converted further suffer from installation costs which are largely unnecessary in other systems. Wherever an extensive railway system is in question, it becomes essential, with continuous current at 3,000 volts, to transform and convert the energy; while with single-phase current at 15,000 volts, transformation alone is required. It is therefore important to investigate the main features associated with transmission and distribution in the different systems and their influence on capital expenditure. First with regard to the number of feeding points at which energy is supplied to the overhead conductors. The distance between these points will be affected by the local conditions of the railway network, such points being fixed at traffic junctions as far as possible, in order to obtain the best results. Attention must further be paid to the permissible drop of voltage in the conductors and rails, and on the possible inductive effects on neighbouring communication circuits.

For the same cross-section of conductor, the higher the voltage, the greater the distance between feeding points. Suppose, for example, that 3,000 kw. has to be transmitted in one direction with a pressure drop of 30 per cent. Assuming cross-sections of 200 mm.² and of 800 mm.² for the overhead conductors with continuous current, and of 200 mm.² with single-phase current, since in this case impedance makes it useless to exceed a copper section of 150 mm.² to 200 mm.². The rails, which in each case act as return, weigh about 40 kg. per metre. The following results are then obtained:

——	Continuous Current.		Single-Phase.
Section of overhead conductor	200	800	200 mm.²
Resistance per Kilometre of track:			
Overhead conductor	0·08	0·02	Ohm
Rails	0·02	0·02	,,
Total	0·10	0·04	(Approx.) 0·24 ,,
Power at receiving end	3,000	3,000	3,000 kw.
Pressure at feeding point	3,000	3,000	15,000 volts
Pressure at receiving end	2,100	2,100	10,500 ,,
Current in conductor ..	1,430	1,430	220 amp.
Transmission distance ..	6·3	15·7	58·5 km.

From this example it is seen that for the same cross-section of copper and the same percentage drop, the single-phase system extends 9·3 times the distance of the continuous-current system; and nearly four times the distance when the copper in the continuous-current system is quadrupled. If the calculations were based on equal energy loss instead of equal pressure drop, the differences would

be still greater; since for the same pressure drop, the loss in continuous-current lines is in general greater than in single-phase lines. From these considerations the conclusion can be drawn that an extensive 3,000-volt, continuous-current system needs three to four times as many feeding points as a 15,000-volt, single-phase system. Obviously the special conditions of every railway network must be considered, such as the geographical position of the several branches and junctions, the gradients, and the average and maximum load conditions. The machinery at every feeding point must be able to deal with the maximum load, consequently the load factor at each point in the continuous-current system will be lower than in the single-phase system, which serves a much wider area. Though a general law cannot be here established, it can be estimated that if the average and maximum loads at a feeding point have a ratio of 1 : 6, with continuous current, the corresponding ratio with single-phase current will be about 1 : 4.

An interesting practical example is afforded by a comparison of the network of the Bernese Railways using single-phase current at 15,000 volts with continuous current at 3,000 volts. In the former—the actual case—the line is fed at Kandergrund and at Spiez with single-phase current direct from the generators without transformation; in the latter case there would be in addition four substations (at Berne, Zweisimmen, Kandersteg and Ausserberg); while much larger overhead conductors and some new transmission lines to the substations would be necessary. The continuous-current system would need about 51,000 kw. additional converting machinery, 340 tons of extra copper for overhead conductors and 70 km. additional transmission lines.

The cost of this extra equipment is shown below, alongside the actual constructional costs of the single-phase installation. In these figures, in addition to the complete track equipment, are included the costs of the works carried out in connection with the communication circuits, but not the costs of the water-power stations. The figures for the single-phase are the actual costs, those for continuous current the calculated costs. The prices are in francs :—

——	Single-Phase.	Continuous Current.
(*a*) Pre-war cost of the original section, Scherzligen-Spiez-Frutigen (1-phase)	3,430,000	3,430,000
Extra for continuous current ..	—	2,134,000
(*b*) War cost of the new sections in 1919 and 1920 (1-phase) ..	12,800,000	12,800,000
Extra for continuous current ..	—	4,406,000
Total (*a*) + (*b*)	16,230,000	22,770,000

Extra for continuous current = 40 per cent.

The increase in the installation costs in the continuous current project is seen to be considerable. The effect of the numerous converter stations is still more pronounced when the production costs of energy are compared. Assuming that about 24,000,000 units are produced annually at the generating station at an average cost of 5 centimes per unit, which corresponds to the present single-phase service, and taking into account loss in conversion, operating costs, interest, renewals and sinking fund for the extra outlay for continuous current, the figures in francs are as follows :—

Annual Energy Costs of the Whole Network.

——	Single-Phase.	Continuous Current.
Traction : 24,000,000 units at 5 centimes	1,200,000	1,200,000
Extra for conversion losses—20 per cent.	—	240,000
Service of converter stations ..	—	100,000
Interest, renewals and redemption —10 per cent.	—	654,000
Total	1,200,000	2,194,000

In this case, therefore, the additional cost of energy with continuous-current traction amounts to 83 per cent.; while no advantage whatsoever accrues from this increase.

In the foregoing example, the conditions for single phase are very simple, because the distances are such that no pressure transformation is necessary. Should double transformation be essential, however, on account of transmission, it remains to be seen whether it is better to transmit the energy as three-phase current at 50 cycles, or as single-phase current at 16 cycles. In the simplest case of a transmission at a fairly low pressure, the cross-sections of copper, for the same pressure drop and energy loss in both cases, are as 3 : 4. This ratio will be modified for high-tension when inductance, charging current and corona effects have to be taken into account, and the factors of safety for the insulation are made approximately equal. The way these influences react on the design of a transmission is best illustrated by means of an example.

Assume that a power of 20,000 kw. at the receiving end has to be transmitted over 250 km. under the following conditions :—

Three-phase : 50 cycles ; cos $\phi = 0 \cdot 9$ at receiving end.
Single-phase : $16\frac{2}{3}$ cycles ; cos $\phi = 0 \cdot 8$ at receiving end.
Pressure between conductors : 150,000 volts.
Cross-section :
Three-phase : 3×200 mm.^{2} aluminium.
Single-phase : 2×300 mm.^{2} aluminium.
Distance between conductors : 3·5 m.

Results.	Three-Phase.	Single-Phase.	
Ohmic pressure drop ..	3·5	5·3	per cent.
Ohmic loss	3·9	6·6	,,
Inductance	0·0011	0·0024	henry/km.
Ohmic resistance	0·143	0·19	ohm/km.
Inductive resistance ..	0·346	0·25	,,
Capacity	0·0092	0·0048	mcf/km.
Charging current	63	19	amperes
Critical pressure at 40 deg. C. and a bar. ht. of 700 mm. ..	151,000	200,000	volts
Total* pressure drop ..	3·9	7·4	per cent.
Total loss	3·6	5·8	,,

* From geometrical resultant of resistance, inductance and capacity.

Thus for equal weights of conductor, the single-phase case would have nearly double the loss of the other. On the other hand, the single-phase system has greater safety in respect of corona discharge and needs fewer insulators—namely, two for 150,000 volts, compared with three for 150,000 volts, when the mid-points of the systems are not earthed; or two for 75,000 volts, compared with three for 87,000 volts, when the mid-points are earthed.

From the point of view of the critical pressure, the single-phase transmission can be worked at 200,000 volts, against 150,000 volts for the three-phase. In this case, with unearthed mid-points, there would be two 200,000-volt insulators against three 150,000-volt insulators, so that the number of elements in the suspension insulators would be about the same for both systems. Retaining the previous conductor sections, the single-phase drop and loss become : Pressure-drop, 3·85 per cent.; loss, 3·25 per cent.—thus approximately the same as for three-phase. This example shows that it is possible, by suitably choosing the conditions, to make single-phase transmission at least as economical as three-phase transmission with the same factor of safety.

The only point in connection with the cost of the transformers lies in marked handicap of the single-phase transformer, on account of the low frequency of the railway system. The additional cost rising from this is, however, negligibly small in comparison with the conversion sets which are needed for the three-phase—continuous-current transmission. Including the two high-tension transformers, the cost of these conversion sets can be taken as about double that of single-phase transformers without conversion. In this estimate the actual lines have been omitted—for these it has been shown that the difference would not be considerable. Further, it must be remembered that the single-phase sets required have a much smaller total capacity than the more numerous and less efficient groups required by three-phase—continuous current case.

In the case when traction current has to be taken by conversion from a three-phase network, it is more economical to convert from three-phase to single-phase than to continuous current because the plant is better utilised with the larger area. The fact that continuous-current generators are somewhat cheaper than single-phase generators of like output can scarcely compensate for the former saving. Summarising, it can be said that the distributing installation for the single-phase system shows much lower capital costs, both in the case when the energy is generated and transmitted in the form of single-phase current, and in the case where three-phase energy has to be converted into single-phase energy; though in the latter case the saving is not so considerable.

(To be continued.)

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 21.)

ON the members reassembling at the Collège de France, on Wednesday morning, the 5th inst., the secretary announced the names of new members, and then referred to the panel exhibited in the room, containing three sizes of sidelights, now being manufactured by the Ateliers et Chantiers de la Loire, Nantes,* and invited the members to examine these sidelights after the reading and discussion of the two papers on the list.

STABILITY OF LARGE SHIPS.

The first paper taken at the meeting of Wednesday dealt with the "Stability of Large Ships," and was by Sir John H. Biles. We reproduce it on page 55. In regard to the diagram in the paper giving the angles of heel caused by squalls and by steady winds, the forces given below it, on the Beaufort scale, were fixed on the latest information obtainable from the Meteorological Office; it might be taken Sir John added, that this latest information from that office was the best available at the present moment.

The discussion was opened by Sir Westcott Abell, who thought the Institution was indebted to Sir John Biles for affording an opportunity for discussing the question of stability of large vessels, owing to the increase in complexity of the conditions which now surrounded both their building and their operation. Where there was free oil fuel, free water, in one word swinging ballast, amongst other conditions, it was particularly desirable to go fully into the question of stability, to study it completely both dynamically and statically. The initial stability, first of all, had to be carefully gone into. The author had assumed the wind pressure to be in the form of a gust and had calculated the effect of this upon the angles of heel. What was wanted was that a standard wave should be taken for studying the dynamic behaviour, also a standard wind pressure, arriving by calculation at the upsetting couple and wind couple, revealing in this way the behaviour of the vessel. The author's paper would, he thought, lead to the fixing of standard conditions for comparison with standard ships.

Professor Hillhouse regarded the subject dealt with as one of very greatest importance; the first requirement of a ship was that it should float, and secondly and equally important was the requirement that it should float upright. The problem of stability in a ship was therefore the first one to consider. The relation of the breadth of a ship as compared to the length was a good way of considering resistance to propulsion, but for stability the breadth should be considered relatively to the depth and draught. A larger ship had a longer sheer than a smaller one. (At this point, Professor Hillhouse compared under this head the Campania and the Empress of Canada.) The author, in the commencement of his paper, had referred to the tendency which existed of having the centre of gravity of a ship raised during its construction, as a result of alterations demanded by the owner whilst actual construction was in progress. In this connection, the saying that "there was always room at the top" seemed to be pretty regularly followed to the letter, and the result, he repeated, was that the centre of gravity rose also. In the presence of such requests on the part of the owner, the builder should state that the position of the centre of gravity required revision, that more additions in the upper parts meant less stability. On the other hand, it was bad to throw

* See ENGINEERING, vol. cxiii, page 814.

doubt upon the stability. One could not hope to measure at any time the actual stability of a ship; the holds did not contain a homogeneous cargo; the feed water and the oil fuel surfaces were free and affected the metacentric height, and therefore the figure given for the metacentric height was a relative figure only.

Professor Welch said the author had started out in the attempt to arrive at the requisite stability for large ships, and had dealt with the problem comparatively, which was the only possible manner of dealing with it. All would agree that Sir John Biles had taken all the necessary factors so far as related to the ship in an intact condition. One should bear in mind that the ship might be struck in a collision. In this case the metacentric height would vary, and one would wish to have a larger reserve than was the case with the ship in an intact condition. This was a difficult point, but it should be borne in mind. Professor Biles had fallen into an error of expression when he referred to the centre of gravity of the volume of the compartments of a ship, this was an expression from earlier times; gravity implied weight, and the author was of course thinking of it in that sense. Dealing with the stability of a ship at sea, and under the heading "the action at sea," the author had said that the period of a ship varied as the beam and inversely as the metacentric height; this, said Professor Welch, should read as the square of the metacentric height. The first part of the paper was an eloquent plea to the port authorities for the deepening of channels and harbours. He asked whether Sir John Biles had met with a formula according to which increased draught due to heel was given by $\frac{1}{10}$ the beam in feet, multiplied by angle of inclination in degrees, less rise of floor in inches.

Mr. Bertin here stated that he had dealt with ships' stability fifty years ago, and at one time he had been asked to design a ship of 10,000 tons, whilst the programme for her artillery, protection and machinery would have required 15,000 tons. He designed the ship and did not exceed 8,000 tons to 8,800 tons, but gave the belt armour a height of 80 cm. (31·5 in.) instead of 2·5. m. (8 ft. 2⅜ in.), and varied other conditions. The rolling of that ship, a very stable one, might have been dangerous. The ship was built and entered the service as a coastguard vessel, not as a battleship.

Mr. W. J. Lovett stated that we owed to France our original knowledge as to the stability of ships, and the places where the meetings were taking place formed probably the birthplace of ship stability conceptions. It seemed to him that several factors came in and had to be borne in mind when considering the question. There was, in the first place, legislation, both as it affected passengers and owners. Legislation had resulted in deeper ships; the owners would not sacrifice in the matter of draught. The ships had a higher freeboard, were deeper. Boats for all were demanded, hence the boats, their davits and platforms, all of which went on top. The passengers' present demand for fresh water had no comparison with the quantity formerly provided. The owners were hard pushed at the present time to make a profit, at all events they said so, and asked for absolutely every possible economy. The ordinary reciprocating steam engine had had its day, and there were on the market several types of internal-combustion engines to take its place. Some owners, for their part, required oil fuel, and if the resulting cost were low they would adopt it. Board of Trade requirements in this connection had to be met. Bottom tanks had to be provided for carrying the oil fuel, and these could not be used as they were for taking water ballast. Owners also wanted a quick turn round, and in a quick turn round the oil fuel tanks could not be washed out.

Sir John Biles, in the course of his reply, stated that Sir Westcott Abell's suggestion of standard conditions under which to measure the dynamic stability of ships was one deserving of great consideration. Professor Hillhouse was at the present time carrying out experiments in Glasgow using a "rolling machine," and he (Sir John) thought that one could look forward to the results revealed by that machine for illustrating the conditions under any series of circumstances that could be set to it. This would lead up to the standard conditions referred to by Sir Westcott. He thanked Professor Hillhouse for his remarks; Professor Hillhouse was associated with him (Sir John) in the work. Professor Welch had alluded to stability in the flooded condition; that condition was taken in account by the Bulkhead Committee and was closely followed by the Glasgow research students, but it was practically impossible to bring it within the scope of the paper. It might perhaps be possible to bring in the flooded condition in the experiments with the "rolling machine" just mentioned. He asked whether Professor Welch required greater stability so as to have a reserve for the flooding condition. The beam and depth dimensions came in, and the point was hardly within the scope of the paper. Mr. Lovett had given a number of interesting facts which had to be taken into account in the designing of ships. Referring again to Professor Welch's remarks, Sir John said he had spoken of the centre of gravity of a volume, and did not assume a vacuum. It was a great pleasure to him (the speaker) to have been associated in the discussion with Mr. Bertin, whom he had always remembered as a great authority on the rolling of ships. Mr. Bertin's work was a classical one for the Institution. Mr. Bertin referred to a ship he had designed, which was so stiff that it could not roll. He (the speaker) did not propose to build such ships, but would make experiments on those lines. Sir John referred here to the ship built by Sir Henry Bessemer,* a ship which "turned round the passengers," but was not found satisfactory. Legislation, as Mr. Lovett stated, had certainly greatly affected shipbuilding. At one time, by reason of legislation, a ship could not have more than a given number of decks, then the difficulty of upper works was removed, since when these have been piled up one upon the other. There was, so to speak, an increased "sail area," but with this difference that in these modern ships one could not "take in sails," and the effect on the structure of a high wind was most important. The increased number of boats also added to the top weight. In new ships, knowing the weight to be provided for, suitable arrangements could be made, but that was not so in the transformation of older ones.

The chairman found the paper a most interesting one, and one that would provide a foundation for further study of the subject; he also paid a tribute to the work in naval architecture carried out by Mr. Bertin, one of the foremost authorities in all naval matters.

The Testing of Materials for Shipbuilding.

The second paper taken at the meeting of Wednesday was the one by Professor Guillet, entitled "Some Points of Interest in Connection with the Testing of Materials for Shipbuilding." It was read in abstract by the secretary, in the absence of the author. We reproduce it on page 57.

The discussion was opened by Professor Dalby, who congratulated the author upon bringing together in a concise form many of the tests specified in ship construction. Here Professor Dalby showed a number of slides illustrating his own tensile tests made with test pieces having two flanges, also diagrams giving the limit of elasticity and of proportionality. A slide was also shown of his machine with which a diagram of the actual test is obtained direct. Such diagrams for iron, mild steel, phosphor bronze, brass and various steels were exhibited by Professor Dalby, who pointed out the variations in the different curves and the way in which the various characteristics of the metals were depicted. Other diagrams showed the shearing stresses and gave information regarding the fatigue limits of metals. Professor Dalby added that he had recently built a machine for torsion tests.

Mr. Doyére, who followed, said he was not a specialist in metallurgy and was not in a position to go deeply into the question dealt with by Professor Guillet and by Professor Dalby. He viewed the matter purely and simply from the standpoint of a naval constructor, and in that light he would connect the explanations given by the two above-named professors with the two papers by Sir Eustace T. d'Eyncourt and Major Fea, read on the preceding day. In the latter papers, progress in naval construction was forecasted, and improvement in the qualities of the materials used was foreseen. Improvement in the qualities of steel would result in decreasing the weight of the hulls. He would like to emphasise a point mentioned by Professor Guillet, to the effect that whatever might be the treatment steel was made to undergo, and whatever might be, therefore, the breaking strength or elastic limit, the modulus, or coefficient of elasticity for all steels remained constant. This tended to diminish the confidence one had in steel. Vibrations and deformations in ships' hulls could not exceed a given limit; the coefficient of elasticity remaining constant, one grade of steel would lead to a decrease in the weight of the hull, but would be at the same time more liable to undergo deformation.

Sir Archibald Denny called attention to the apparatus devised by Mr. Stromeyer and used at the National Physical Laboratory, for torsion tests, which appeared to be very promising. He entirely shared Mr. Doyére's views. He called attention to work carried out by the International Association for the Testing of Materials, whose meetings had been interrupted by the war. Also to the specification No. 131 issued by the British Engineering Standards Association, and pointed out the similarity which existed between the British tests and measurements and the French.

On the motion of the chairman, both Professor Guillet and Professor Dalby received the thanks of the meeting for their contribution and remarks.

Before the members separated, Mr. C. Laupretre, of the Ateliers et Chantiers de la Loire, Nantes, explained the working of that company's hinged and pivoting sidelights (illustrated on page 814 of our issue of June 30 last), three of which were mounted on a panel in the hall as above stated.

(To be continued.)

* See ENGINEERING, vol. xix, p. 227.

HULL.—The Port of Hull Annual for 1922, edited by Mr. H. E. C. Newham, serves to draw attention to the large volume of trade which is now dealt with from this base. The shipping facilities are extremely good, with docks up to modern requirements, and ample convenience for transhipments from rail to boat and *vice versâ*. The port is one of the most important for fuel oil; it does more in "soft fruit" than any other port in the Kingdom; its seed crushing industry represents, we believe, the greatest concentration of this trade in the world, while its activities include regular wool sales, flour milling, fishing, tanning, &c. It has 10 docks of a water area of 235 acres. The annual, which may be obtained at 3*s.* 9*d.*, post fee, from the editor, Bishop-lane, Hull, contains informative articles on all the leading industries of the port, with useful statistical data.

THE MARCONI INTERNATIONAL DIRECTORY.—The first edition of the Marconi International Directory, Buyers' and Exporters' Guide, which will be issued annually in future, has just been published, and is now obtainable from the Marconi International Code Company, Limited, Marconi House, Strand, W.C. 2, at the price of 25*s.* It consists of a volume containing upwards of 1,100 pages, measuring 9½ in. wide by 12½ in. deep, strongly bound in green cloth-covered boards. A considerable part of the work is occupied by a list of over 40,000 firms in all parts of the world, arranged in alphabetical order irrespective of nationality. In each case the full title of the firm is given and the nature of its business is indicated, while the postal and cable addresses are stated; an alphabetical list of cable addresses is also given in a separate section. Another important section gives the names of the principal firms classified according to the trade in which they are engaged, the names under each trade heading being arranged under sub-headings according to nationality. It is thus possible to obtain at once a list of the firms engaged in any business in the whole world or in any particular country. Indexes to this section are printed in French, German, Italian, Spanish and Dutch, and an introduction to the whole work, explaining its uses, is also printed in these languages as well as in English. On the whole we think this directory will serve a very useful purpose, although there is room for improvement of the classified trades section as far as certain engineering products are concerned. For instance, under the heading "Dies and Taps" the name of no British firm occurs, and the same remark applies to "Drills, Pneumatic," "Pipes, Wrought Iron," and "Pumps, Motor," to mention a few we happened to notice. In other cases, the lists of names are by no means complete; there are certainly more than two firms making steam pumps in England, and more than one firm making turbine pumps. We fully appreciate the difficulty of preparing such lists, however, and only draw attention to these points to indicate that discretion is necessary in using a directory of this kind.

THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

(*Concluded from page* 11.)

ONE missed at the Show the very elaborate displays which had been made on previous occasions by an organisation desirous of popularising the use of ferro-concrete, but advocates of this material could see it applied to a very unusual purpose on the stand of Messrs. E. H. Benthall and Co., Limited, of Heybridge, near Maldon, Essex. This firm had a large display of farm machinery of various kinds, but their exhibit of the greatest engineering interest was a grinding mill, of which everything but the working parts was made of ferro-concrete. Photographs of this mill are reproduced in Figs. 11 and 12, annexed. It had 8 in. grinding plates, and except for the material of its framing and hopper was of the usual design. It was constructed of three main ferro-concrete castings, cemented together, and though apparently a good deal heavier than the ordinary iron mill, was decidedly cheaper, and, of course, practically indestructible. The mill had working parts interchangeable with those of Messrs. Benthall's ordinary mills, and the bearings were self-aligning and renewable.

Refrigerating machinery, as usual, was not nearly so much in evidence as it ought to be in a show such as that of the Royal Agricultural Society. There was no large machinery of this kind at all, and the smaller plants were by no means as conspicuous as the field for them would warrant, three firms only exhibiting them. Messrs. Parnall and Sons, Limited, 27, Summer-row, Birmingham, showed a small ammonia plant with cold storage chamber for butchers' use, made by Messrs. Thomas Hall and Son, Limited, of Masborough-street, Rotherham. The storage chamber measured 6 ft. 6 in. by 4 ft. 6 in. by 6 ft. high, internally, and the machine was rated at 6·5 cwt. of refrigeration per 24 hours. Messrs. John Kirkaldy, Limited, of 101, Leadenhall-street, London, E.C. 3, also showed plant for very similar duties. Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, of 8, Great George-street, Westminster, S.W. 1, confined their display principally to small internal-combustion engines of the four-cycle vertical totally-enclosed type. One of these was shown driving an attractive and compact ice-making machine, built by the Pulsometer Engineering Company, Limited, of Reading. This was of the ammonia type, and made ice in 9 lb. batches, the output under English climatic conditions being 216 lb. per 24 hour day. The whole machine weighed less than half a ton, and occupied a floor space of only 25 in. by 38 in. It required only 1 b.h.p. to drive it. The compressor cylinder was machined from a solid block of forged steel, and the ammonia valves and fittings were made in a similar way. For country house use, or for any place where small quantites of ice are required, the machine should be very useful, as its construction was simple and substantial.

Cable ploughing outfits were shown, as might be expected, by Messrs. John Fowler and Co., Limited, of Leeds, and Messrs. J. and H. McLaren, Limited, of the same town. Both firms showed both oil-driven and steam-driven machinery of their well-known types, which we have illustrated in these columns on previous occasions. This year there was a German competitor in the field, namely, a cable-ploughing engine built by Messrs. A. Borsig of Tegel, near Berlin, and shown on the stand of Mr. F. A. Standen, of St. Ives, Hunts. This was a somewhat crude-looking machine, but it appeared very capable of doing its work, and reports from a farm a few miles away where a pair of such engines were working with a four-furrow plough, were quite favourable. Contrary to British practice, the motive power was furnished by a single cylinder open-type horizontal engine mounted in the centre of the girder frame. This drove the rope drum, which was carried just inside one of the rear wheels in much the position of the flywheel of a traction engine, by means of machine-cut spur gearing. The rope was led away by means of guide pulleys, so that it left the machine transversely under the centre of the framing. The engine was of the four-cycle type developing 40 b.h.p. at 360 r.p.m., and gave a rope pull of 5,000 lb. The machine had two road speeds of 1·5 m.p.h. and 3 m.p.h., and a reverse. It also had two ploughing speeds of 2 m.p.h. and 3·5 m.p.h., respectively. The weight of the machine was 8·5 tons. Two such machines operate a 2-ton balance plough, with 500 yards of $\frac{3}{8}$ in. cable. The price of such an outfit is vastly lower than that of competing British machines, and this is not to be explained away by the depreciation of the mark. We think it would be well for our own manufacturers to study the design with care, for its rugged simplicity is certainly attractive to those who know the conditions under which agricultural machinery has to work.

For pumping large quantities of water on more conventional lines, the machinery shown by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford, and Messrs. Charles Lack and Sons, Limited, of Cottenham, Cambridgeshire, was noticeable. The former firm had a large display of centrifugal pumps of various sizes, from 4 in. to 10 in. suction, and also of vertical heavy oil engines ranging up to 50 b.h.p. All the centrifugal pumps shown had the horizontally-split casing, which is such a convenience for inspection of the impellers. A 6-in. pump driven by a 15 b.h.p. oil engine discharged water over an illuminated fountain in a manner very attractive to the passers-by. The most imposing pump at the show was certainly that exhibited by Messrs. Charles Lack and Sons, Limited, which we illustrate in Figs. 15 to 19, on page 39. This, which was shown working on the stand, was built for pumping sewage, slurry or similar gritty liquids. It had three single-acting plungers, each 10 in. diameter by 18 in. stroke, and the crankshaft ran at 25 r.p.m. The valves were of flat metal, faced with rubber, and neither in the valve chests nor elsewhere were any places which were likely to be clogged up. The design of the valves and seatings is shown in Figs. 13 and 14, subjoined. Each valve is guided by a round spindle fixed in the centre of the cover. The end of the spindle enters a pocket in the valve, and the liquid in this pocket exerts a cushioning action as it can only escape through a constricted area, so that all tendency to hammering is prevented. The cover is held in position by a clip which is tightened by a single set screw, and consequently the inspection or renewal of any valve can be carried out in a minute or so. Pumps of similar design, but with two barrels only, are also manufactured by the firm.

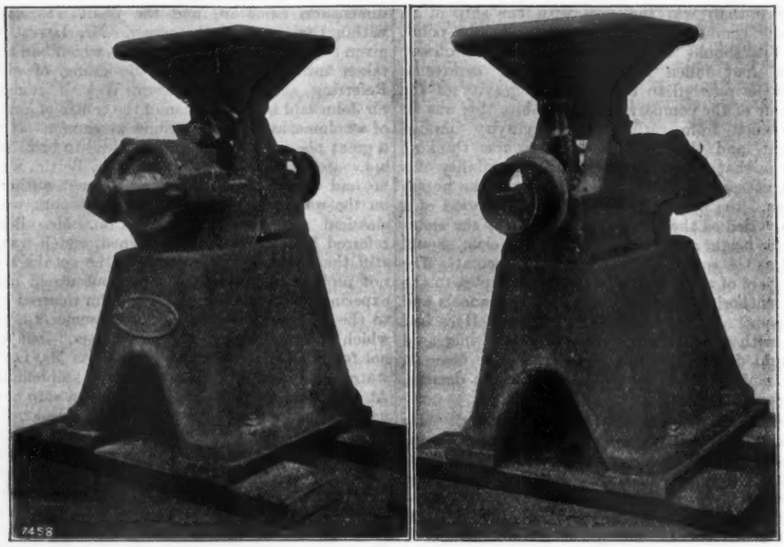
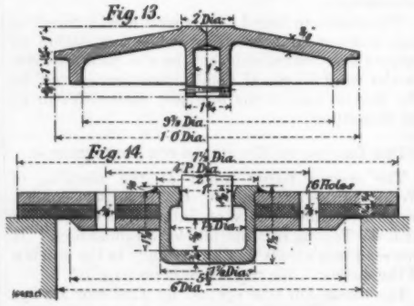


FIG. 11. FIG. 12.

FIGS. 11 AND 12. GRINDING MILL WITH CONCRETE FRAME; MESSRS. E. H. BENTHALL AND CO., LTD.



FIGS. 13 AND 14. DETAILS OF VALVES FOR SEWAGE PUMP; MESSRS. CHARLES LACK AND SONS, LIMITED.

Among the steam road-rollers at the Show, the most novel in design is that shown by Messrs. Aveling and Porter, Limited, of Rochester. The roller is of the tandem type for tar macadam and bituminous road carpeting. One of the essential features of machines to work on hot asphaltic material is that quick reversing shall be possible, for if the machine rests stationary for more than a moment the work is spoiled. The frame of the roller in question is of steel channels, and about midway between the rollers is a vertical boiler with a two-cylinder simple engine lying alongside it. Double-reduction, machine-cut cast-steel spur gearing transmits the power from the crankshaft to the back roller. Both cylinders are high-pressure ones, and this fact and the use of simple radial valve gear enables reversal to be effected very quickly. The boiler pressure is 150 lb. per square inch and the cylinders are 5 in. diameter by 5 in. stroke, a brake horse-power of about 17 being developed. The front rollers are 39 in. diameter and the back roller is 42 in. diameter. The wheel base of the machine is 9 ft. 5 in. long and the working weight about 6 tons. A width of 4 ft. is rolled. Steering is effected by a three-cylinder radial engine driving a worm gear, but hand steering by means of a wheel on the worm shaft is also provided. An internal brake, working against a renewable ring bolted to the hind roller is fitted, together with other accessories, for easy and safe operation of the machine.

Several developments in connection with steam wagons were to be seen at the show. We have already mentioned the six-wheeled vehicle entered by Messrs. W. Tasker and Sons, Limited, of Andover, Hants, which really consists of an ordinary steam wagon, the platform of which is replaced by a turntable supporting the front end of another platform. This latter carries the load, and has two road wheels at the rear. It is obvious that such a construction permits a larger platform area and a greater load-

SLUDGE AND SEWAGE PUMPS AT THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

CONSTRUCTED BY MESSRS. CHARLES LACK AND SONS, LIMITED, ENGINEERS, COTTENHAM, CAMBS.

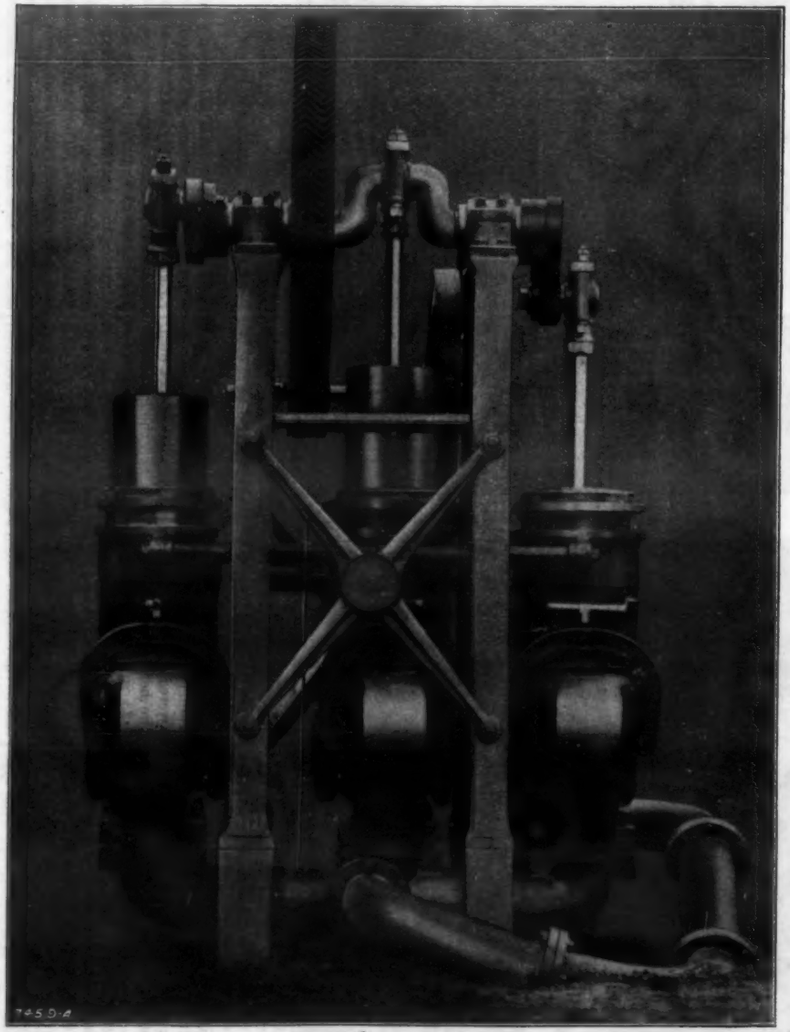
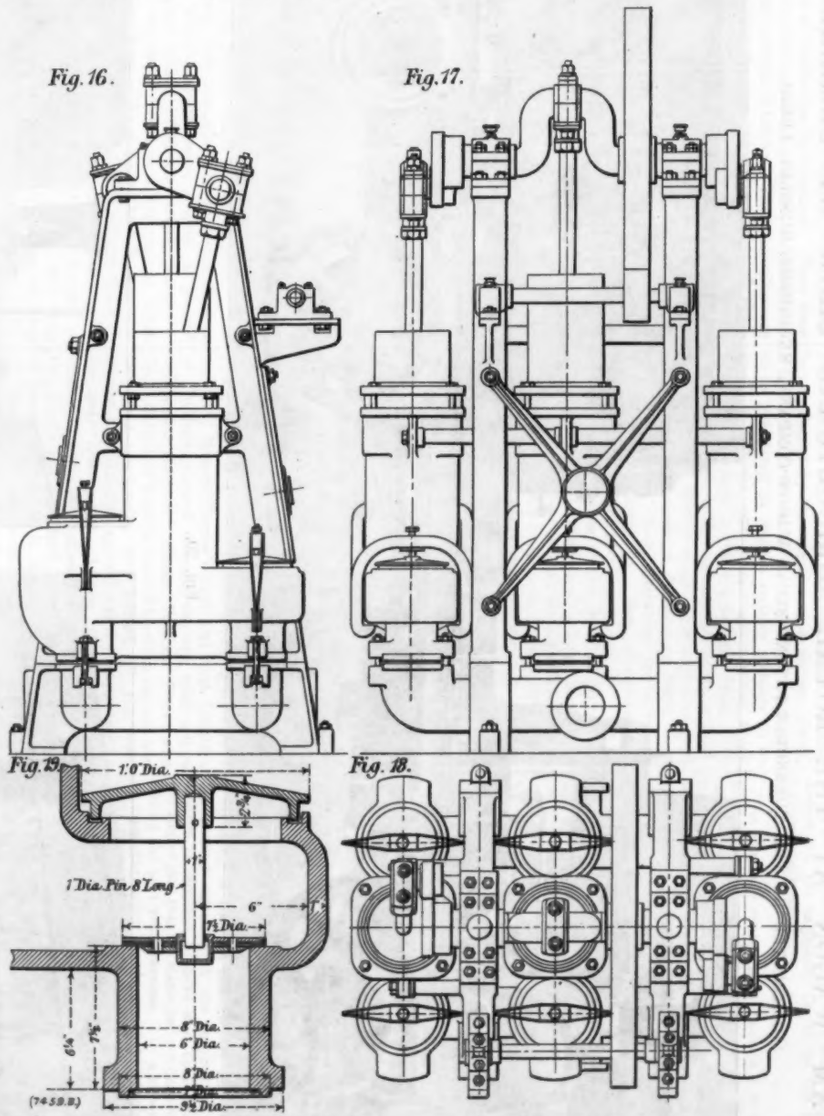


FIG. 15.



carrying capacity without increase of axle weights. Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich, have carried the idea a step further and have produced a very imposing vehicle. This consists of a steam wagon, to the rear end of which a two-wheeled attachment is coupled by means of a long pole. The connection of the pole to the wagon is made by a universal joint. The load-carrying platform rests on two turntables, one on the wagon chassis, and the other on the top of the two-wheeled trailing attachment. Thus a six-wheeled vehicle is obtained which is sufficiently flexible to accommodate itself to any inequalities of road surface without strain, and of which the trailing wheels will follow in the track of the driving wheels when the vehicle is turned. This Ransome lorry with attachment,

STEAM WAGON AT THE ROYAL AGRICULTURAL SHOW AT CAMBRIDGE.

CONSTRUCTED BY THE YORKSHIRE PATENT STEAM WAGON COMPANY, ENGINEERS, HUNSLET, LEEDS.

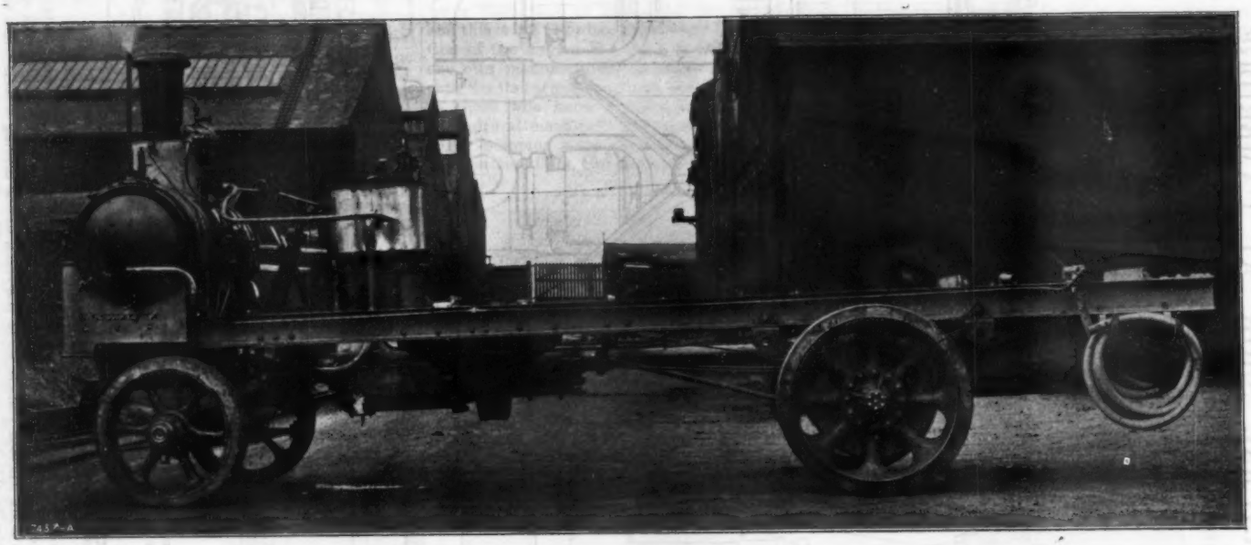


FIG. 20.

FIG. 21.

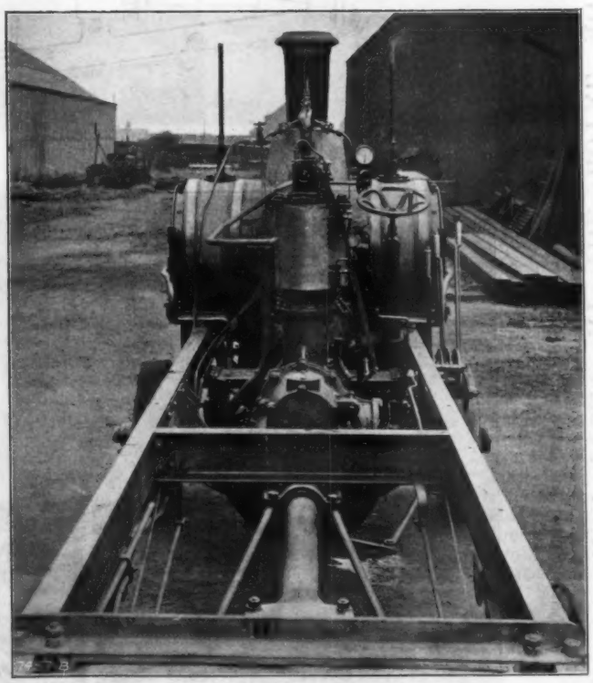


FIG. 22.

which we illustrate and describe fully on page 54, is capable of carrying loads up to 10 tons, and as the body is more than twice the length of that of an ordinary steam wagon, very bulky loads can be transported.

Another novelty in the way of steam lorries was shown by the Yorkshire Patent Steam Wagon Company, of Hunslet, Leeds. This we illustrate in Figs. 20 to 22, above. It weighs under 6 tons, unladen, and will carry a useful load of 7 tons. The boiler and superheater are of the type adopted as standard by the makers, the cross-wise arrangement permitting the vehicle to work on any gradient without the fire-box or tubes being uncovered. The working pressure is 200 lb. per inch. The heating surface is 88 sq. ft. and the grate area 3·25 sq. ft. The engine is of the vertical two-cylinder compound type, with cylinders 5 in. and 7·5 in. diameter by 8 in. stroke, running at a normal speed of 380 r.p.m. There is a by-pass valve to enable both cylinders to work with high-pressure steam when starting, or in emergencies. As in the case of the Clarkson steam wagon which we described recently, change-speed gear has been adopted, somewhat on the lines of motor vehicle practice. There are three speeds, of 3 m.p.h., 8 m.p.h. and 12 m.p.h. respectively, with the engine at normal revolutions. The change-speed gear is housed in a casing which registers into the crank-case, so that it makes one unit with the engine. Reversing is done by the engine, which is fitted with Hackworth valve gear. The ground clearance is 12 in., and all parts of the mechanism are accessible without the necessity of an inspection pit. Great care has been taken with the design of the brake gear, the oiltightness of the system, and other

important points, and the design as a whole is well worthy of commendation.

Small pumps for farm and estate use were of course to be seen at Cambridge by hundreds. They were usually driven by petrol or oil engines, and the rotary type appeared much in favour. The windmill seems to be holding its own for pumping, and these machines showed to advantage in the high winds which prevailed during the Show. No new developments, however, were noticeable in their design, and it is questionable whether much improvement is possible. The principle of raising water by means of an endless chain or belt of some kind has quite won a place for itself. A favourite scheme seems to be to lift the water to about ground level by the running chain and deliver it to the suction of a rotary pump which forces it to the required height. Messrs. Boulton and Paul, Limited, of Norwich, showed two kinds of lifting device; both of which we have noticed before. One consisted of an ordinary chain on which were threaded fairly close-coiled helical springs. The other was a canvas and rubber belt, one side of which was covered with loops made by bending thin metal strip into zig-zag form, and riveting it to the belt. Messrs. Siebe Gorman and Co., Limited, of Westminster Bridge-road, London, S.E. 1, showed various examples of the "Aquatole" water lifter which we illustrated in our issue of June 30 last, page 827. The belt in this case is built up of springs threaded together something like a certain kind of door-mat. The Crawley Agrimotor Company, Limited, of Saffron Walden, exhibited another variant of this kind of pump, called the hydrohoist. The water-lifting belt consisted of a stranded wire cable on which were threaded a series of pressed steel saucers which lifted the water positively. Whatever the type of belt used, the general design of all these lifters is the same. The belt runs over a driving pulley and hangs down freely in the well, the bight at the bottom containing a heavy roller to keep the belt taut and vertical. The amount of water they will deliver is astonishing, and their efficiency is quite reasonable. Moreover, as they are entirely valveless and without rubbing parts, any kind of gritty water may be handled without injuring them.

Messrs. Arscott and Mawer, Limited, of Danesgate, Lincoln, showed a device which, though not of great engineering importance, is nevertheless of interest on account of its convenience and ingenuity. It is known as Cade's patent gate, and has been devised to avoid the inconvenience of having to descend from a motor car or a horse to open a gate, and close the gate again and having to remount after passing through. In connection with the Cade gate, there is a long lever near the gate, and when the end of this is pulled down, the usual spring catch is first unfastened by a rod passing through one of the gate-bars, which is made of piping for the purpose. Lowering the lever still more causes the gate to open wide and the catch to engage with a catch plate on a post placed by the roadside. Thus the gate is held securely open. After passing, the person entering pulls down a lever similar to the one he operated on arrival and this frees the gate and closes it behind him. There is nothing whatever to prevent the gate being operated in the ordinary way, as well as by the levers, nor is there anything which might be damaged by or cause injury to cattle. It is said that the Cade gate can be opened and closed after him by a man on a bicycle without dismounting. The gates are made in both wood and iron, and should have a large field of usefulness as the device is both simple and effective.

The show contained very little in the way of instruments of any kind. Messrs. H. G. Burford and Co., Limited, of 16, Regent-street, London, S.W. 1, showed the Watson draw-bar dynamometer which we fully described and illustrated in our issue of June 30 last. This, as will be remembered, was designed to give a graphic record of the work done by tractors in hauling agricultural implements. It was awarded a silver medal by the judges in the "new implement" class. The other instrument was a very inexpensive level by Messrs. T. Cooke and Sons, Limited, of 3, Broadway, Westminster, S.W. 1, for the use of farmers, colonists and contractors. It contained a telescope of 1 in. aperture giving nine magnifications, and the spirit bubble was amply protected by being placed in an enlargement on the top of the telescope barrel, reading being effected by its reflection in a mirror, which, when folded down, acted as a guard. A horizontal circle graduated in degrees enables settings to be made in azimuth, and a micrometer screw which tilts the telescope permits gradients from 1 in 300 to 1 in 600, both rise and fall to be sighted. The instrument was so simple that any intelligent person with no knowledge of surveying could use it for levelling, laying-out irrigation trenches and similar work. Packed in a box, complete with tripod, it only weighs about 10 lb.

In this brief review of the show we have been compelled to omit mention of a large number of exhibitors, either because their stands held little that was novel or which has not been dealt with in our columns. Many of these had striking displays of their standard products. Messrs. Ruston and Hornsby, Limited, of Lincoln, who had one of the largest stands at the Show, exhibited internal-combustion engines, ranging from little hopper-cooled sets of about 2 b.h.p. to large, cold-starting engines for heavy oils. Traction engines, both simple and compound, road rollers, threshing machinery, agricultural tractors, were also in their stand, as well as a gas-producer plant to make gas from wood refuse. Messrs. Clayton and Shuttleworth, Limited, of Lincoln, showed traction engines, steam wagons, two-stroke crude oil engines and threshing machinery. Messrs. Richard Garrett and Sons, Limited, of Leiston, had traction engines, steam rollers, steam wagons and threshing machinery on view; Messrs. Charles Burrell and Sons, Limited, of Thetford, showed traction engines, road rollers and steam tractors; Messrs. William Foster and Co., Limited, of Lincoln showed traction engines and threshing machinery, and indeed all the well-known East Anglian agricultural firms appeared to be well represented. Among the innumerable makers of small oil engines, Messrs. Blackstone and Co., Limited, of Stamford, Messrs. Petters, Limited, of Yeovil, and Messrs. R. A. Lister and Co., Limited, of Dursley, Gloucestershire, must be mentioned, but the impossibility of referring to all the firms showing these articles will be recognised when we state that the catalogue enumerates no less than 60 stands where oil and petrol engines were to be seen. The ingenious sleeve-valve engine made by Messrs. Wallace, Limited, of Dennistown, Glasgow, which we have illustrated on a previous occasion was to be seen driving the machinery of several exhibitors, and the makers were also showing a water-cooled engine built on the same principle. The greatest novelty on Messrs. Blackstone's stand was an oil-driven narrow-gauge locomotive, fitted with a three-cylinder, 25-b.h.p. cold-starting engine. This has been designed for intermittent traffic in works or on plantations. The locomotive has speeds of 2·5 m.p.h. and 7·5 m.p.h. in either direction. It can be built in any gauge from 19 in. to 30 in. Its weight is 3 tons, and it gives a draw-bar pull of 1,200 lb.

INDUSTRIAL NOTES.

THE decision of the Industrial Court in the matter of wages in the printing trade, referred to in our last issue, is that the reductions shall be by 3*s.* per week as from the beginning of the first pay week following the 11th inst.; and a further 3*s.* as from the beginning of the first complete pay week in September next; a further 3*s.* as from the beginning of the first complete pay week in November next; and by 3*s.* 6*d.* as from the beginning of the first complete pay week in January, 1923. A number of unions have accepted the arrangement; in the case of others, further negotiations are taking place.

The joint conference between the Employers' Federation and the engineering trade unions to which we also referred in our last issue, was resumed after we had gone to press. At the resumed sitting the employers proposed that the 16*s.* 6*d.*, part of the war bonus should be withdrawn in three instalments, namely, 5*s.* 6*d.* on the 31st inst., 5*s.* 6*d.* on August 28 and 5*s.* 6*d.* on September 25. The men's representatives decided to submit the proposal to the members of the various unions on a uniform ballot paper, the votes to be returnable by the 23rd inst.

It is announced that the Admiralty has decided to reduce the wages of employees in the Naval Dockyards by 16*s.* 6*d.* per week, at the following rates: 7*s.* 6*d.* from the 16th inst., 3*s.* from August 13, 2*s.* from August 27, the remaining 4*s.* to be the subject of further consideration.

The quarterly report, from January 1 to March 25, 1922, recently issued by the Associated Blacksmiths' and Ironworkers' Society, states that the income for the quarter was 52,280*l.* 7*s.*, this including 40,030*l.* 1*s.* 11*d.* repaid by the Ministry of Labour. The expenditure was 57,526*l.* 10*s.* 7½*d.*, a loss on the quarter's transactions of 5,246*l.* 3*s.* 7½*d.* This left a balance of 38,709*l.* 0*s.* 3½*d.*, from which was to be deducted the sum of 26,561*l.* 0*s.* 8*d.*, money advanced by the society's bankers. The report further states that approximately 50 per cent. of the members are still unable to secure employment.

The National Executive of the Miners' Federation held a meeting a few days ago in London, under the chairmanship of Mr. Tom Richards, when they discussed the question of wages in the collieries. At the close of the meeting, Mr. Frank Hodges, secretary of the Federation, issued the following statement:—

"The Executive Committee had under consideration the wage position in the mining industry, which is gradually becoming worse, and decided to ask the owners to agree to a meeting of the National Board on the earliest possible day, to discuss the general situation, and to request their co-operation in an effort to improve the lot of the workers in the industry.

"The report of the whole situation will be presented to the annual conference of the Miners' Federation, which opens at Blackpool on July 18, when the operation of the national agreement during its twelve months of existence will be reviewed."

Speaking at Ilkeston last Sunday and referring to the present situation in the mining industry, Mr. Hodges is reported to have said that sometimes he felt almost glad that the mines had not been nationalised during the past year, because, "by a superficial form of reasoning, some people would have said that the short time and low wages which existed were exclusively due to the nationalisation of the mines." This would seem to amount to an admission on the part of Mr. Hodges that under nationalisation the mines of the country would be in the same plight as that in which they are now.

Speaking in Parliament last week, in the matter of the coal industry, Mr. Gould (Cardiff) stated that the reason for the high prices now charged to coal consumers was that, apart from wages, colliery charges had increased 140 per cent. The coal industry as a whole could not afford to pay any greater wages than it was paying. Since July last, it had lost over a million and a-half. If there were an inquiry, it could only relate to two points, the effect of a 7-hour day and the increase in charges other than wages. Speaking on the same point, Sir George Renwick (Newcastle) said that railway rates for coal were too high; he added that the Admiralty were only taking half a million tons of coal instead of one and a-half million tons yearly, because the Navy was burning oil instead. Other members asked for Government intervention. In his reply, Mr. Bridgeman said it was apparent from the speeches that the real point was the desire to obtain a subsidy from the Government. With trade as it was, nothing at the moment could benefit the condition of the poorer-paid miners except a subsidy. That meant getting from the rest of the community, many of whom were receiving low wages, or were unemployed, a levy in order to benefit the miners. He did not think it was the slightest use asking the House to agree to any subsidy of that kind. The only hope of improvement lay in an improvement in trade. All the troubles were due to the want of demand for coal. There were signs that the export market was recovering. The mining industry had made greater sacrifices for the sake of economic recovery than any other industry, and it was unfair to ask them to make further sacrifices which other industries were not prepared also to make. He was prepared to submit to the Advisory Committee of his department the question whether there was any prospect of economising in the cost of distribution in railway rates, and other items which made up the cost to the consumer.

The question of safe working in the mines was also raised in Parliament, when a member stated that in 1920 the accidents were more numerous than in any previous year, there having been 1,103 fatal and 11,700 non-fatal accidents in which men were seriously injured. The great enemy of the miner, it was added, was not firedamp, but falls from the roof and sides of the mines, and the danger of haulage roads. The safety men, it was further stated, should be employed and paid by Government and not by the owners. To this, Mr. Bridgeman replied that the question of

THE "ATRITOR" COAL-PULVERISING MACHINE.

CONSTRUCTED BY MESSRS. ALFRED HERBERT, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see opposite Page.*)

Fig. 1.

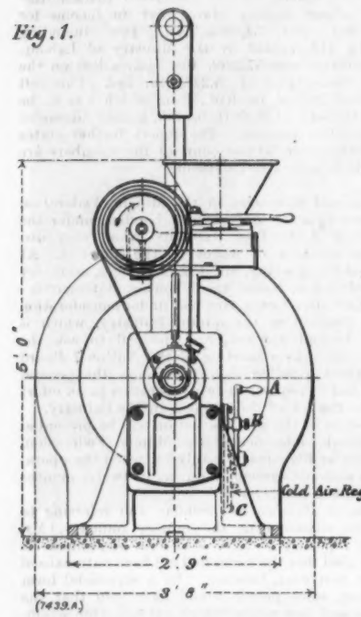


Fig. 2.

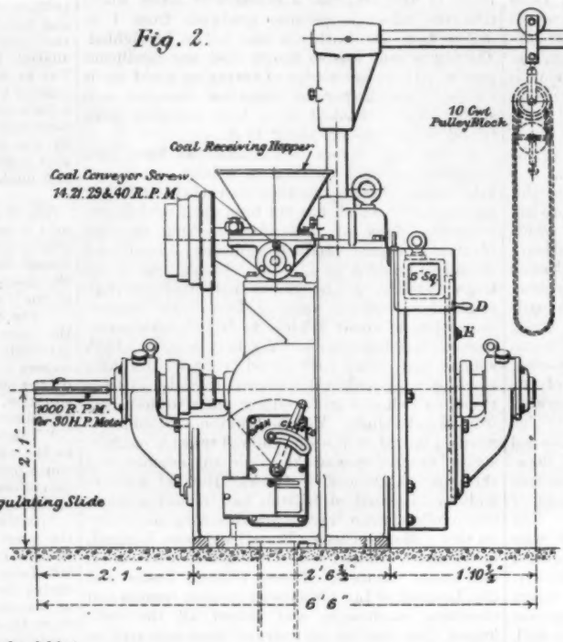
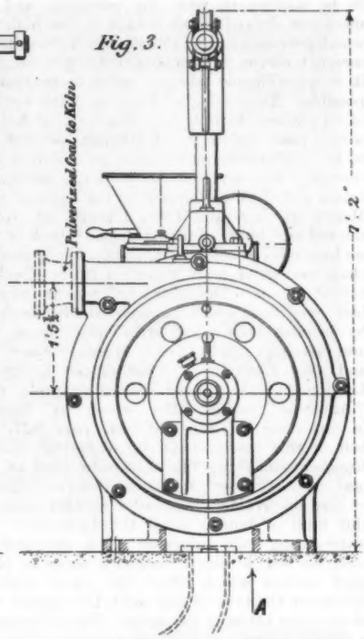


Fig. 3.



safety provided the largest portion of the work of his department, and to him it was the most interesting. He contended that in recent years there had been a decided improvement in the statistics of accidents. It was too much to hope we should ever reach a really satisfactory position. All that could be done was to go on reducing accidents as much as possible. To make the deputies State officials would, apart from the expense, involve dual control of the mines, and that was a fatal objection. The responsibility must rest with the manager.

The question of lighting appeared to have some association with the spread of nystagmus, and by improving the luminosity of the lamps used, and introducing electricity where possible, it was hoped some improvement would be effected. The increase of haulage accidents was a disquieting feature. Many of them were undoubtedly the result of carelessness, and he was trying very hard to introduce a "safety first campaign" in the mines.

Fig. 4.

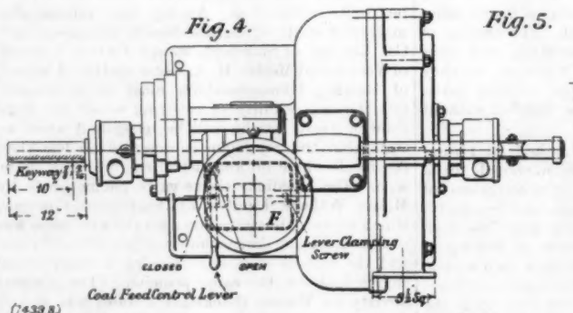


Fig. 5.

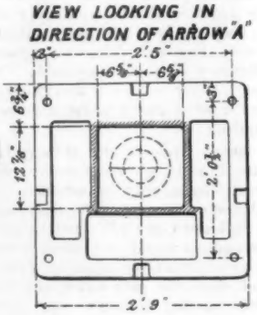
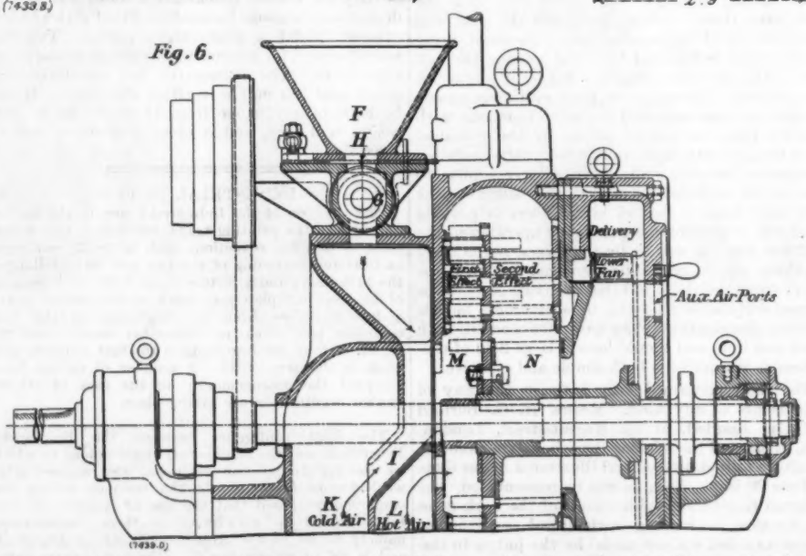


Fig. 6.



COAL-TAR IN ROOFING MATERIALS.—One of the early uses to which coal tar was put industrially was in the manufacture of roofing materials, states the United States Bureau of Mines in a technical paper recently issued. Originally single sheets of millboard were coated with tar and painted with it after they were laid on the roof. Then came the treatment of large rolls of roofing felt, which eliminated the transverse joints on the roof. The present method consists in treating special felt paper with hot tar, and removing the excess of tar by passing the felt between heated steel rollers; from the rollers the felt is run on a spindle and made up into rolls containing 250 sq. ft. or 500 sq. ft. The rolls are then wrapped in paper and are ready for the market. It is often necessary to "age" and "turn" the finished product before marketing; that is, the paper rolls are stood on end and are turned, end for end, every few days for two or three weeks, in order to prevent the paper at one end of a roll from becoming "soggy." Ageing and turning are necessary because the paper sometimes has more tar on it than it can absorb at once. The use of heavy cold tar also aggravates the tendency of the paper to become soggy. Tar paper should always be stood on end when stored.

CANADIAN TIMBERS.—The Imperial Institute Advisory Committee on Timbers is conducting an inquiry into the possibility of extending the use in Great Britain of the timbers produced in the various countries of the Overseas Empire. The attention of H.M. Office of Works was called by the committee to the value of British Columbia Douglas fir, spruce and hemlock for constructional purposes, and it is reported that, as a result of special strength tests and joinery trials, these woods are now included in their official specifications for Government buildings as alternatives to European woods. The Eastern Canadian timbers dealt with comprise softwoods, such as spruce, red pine and yellow or white pine, and hardwoods, including white birch, rock maple, beech and white elm. The committee consider that the qualities of Eastern Canadian timbers warrant a far larger use in this country than obtains at present. Spruce and red pine should find a good market, since they form admirable substitutes for Baltic white and red deal respectively. Yellow or white pine is already well known, but should also be more extensively used. H.M. Office of Works permits the use of these Eastern Canadian timbers if conforming to the official standards of quality. The three soft woods mentioned have also been accepted by the War Office as alternatives to European soft woods.

THE "ATRITOR" COAL-PULVERISING MACHINE.

POWDERED coal, about which much has been written lately in connection with boiler furnace work, has for many years been commonly used in the cement industry for firing rotary kilns. In this application it has been very successful. In this country the material has not been used to any considerable extent for boiler work, although elsewhere, and particularly in the United States, a fair amount has been done with it. The advantages claimed for pulverised coal are very complete combustion, low labour costs, and the fact that low-grade coal can be employed with good results. Among its disadvantages are the costliness of the plant necessary and the inadvisability of storing the powdered fuel, as well as the difficulty and cost of carrying the material to the various furnaces when a central pulverising plant is used in a large installation.

Fig. 7.

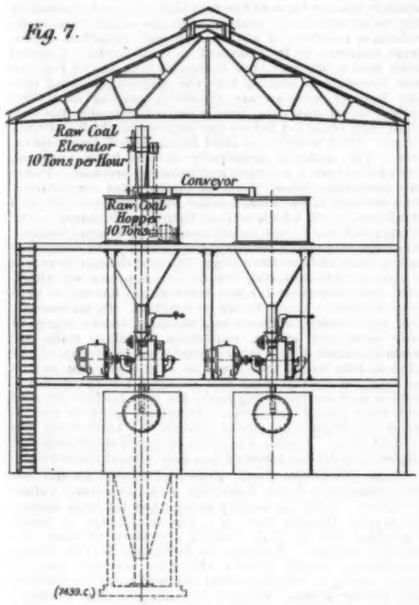
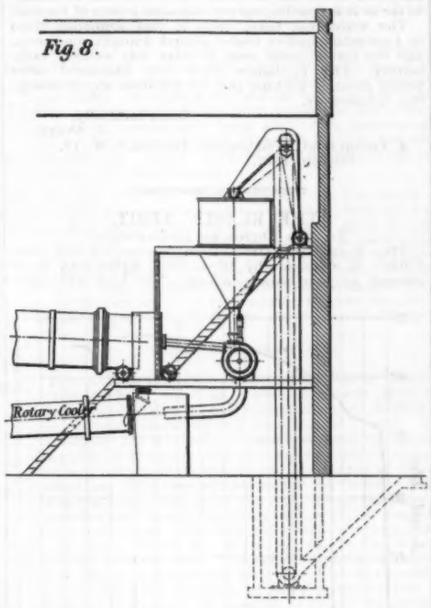


Fig. 8.

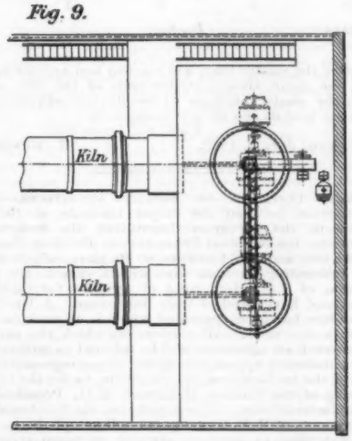


A machine which is claimed to eliminate many of the disadvantages of the ordinary pulverising plant, and which has in practice shown very valuable reductions, both in the cost of pulverising and in the class of fuel necessary for a definite duty, is illustrated herewith and on the opposite page and page 46. This coal pulveriser, which has been named the "Atritor," is the invention of Mr. Charles E. Blyth, of Messrs. Charles Nelson and Co.; cement makers of Stockton, near Rugby. It is manufactured by Messrs. Alfred Herbert, Limited, of Coventry. The machine is in the form of a small self-contained unit which dries, pulverises and propels the coal direct into the furnace, so that there is no storage of pulverised fuel and no long transmission of the product. The machine is continuous in action, and the drying and pulverising go on together, the coal being burned immediately after pulverisation so that there is no opportunity for it to absorb moisture. There are no screens in the plant, so that there is no question of appliances of this kind clogging. In view of the fact that no auxiliary machinery is necessary in connection with the pulveriser, other than some method of supplying the receiving hopper with coal, its cost is very moderate, while maintenance, labour and power required are all brought down to a low figure.

The general lines of the machine will be followed from the illustrations opposite and on page 46. Figs. 1 to 5 are various outside views, Fig. 6 is a cross-section, and Figs. 10 to 12 are from photographs of an actual machine and some of its parts. Coal is fed into the receiving hopper which can be seen at the top of the machine in many of the figures and which is indicated by the letter F in Fig. 6. This hopper is fitted with a feed screw at the bottom, indicated by G in Fig. 6, which is driven from a cone pulley as shown. A lever operated slide, shown at H in Fig. 6, is also fitted to regulate the flow of coal. The operating lever can best be seen in Fig. 10. The coal from the hopper passes down a chute, as shown by the arrow in Fig. 6, and into the separator I. This separator is simply a sloping passage up which a cold air supply enters the machine from the passage K. The air current carries the coal with it, while any pieces of metal or other material of a higher specific gravity than coal pass down the separator and fall out of the machine. The air supply is drawn through an opening in the front of the machine, to be seen in Figs. 2 and 10, the amount of opening being adjusted by a sliding cover which can be seen in these figures and is indicated by the letter C in Fig. 1. The cold air is drawn into the machine by a fan fixed on the far side of the rotor, which serves to deliver the pulverised coal to the outlet. The incoming air current delivers the coal to the rotor, which pulverises it, and the amount of air is adjusted so that all coal passes into the machine and all metal or similar undesirable matter is rejected.

There is a second inlet to the machine, shown at L in Fig. 6, through which air at about 500 deg. C. is drawn. This air supply is drawn from the rotary cooler of the kiln, as shown in Figs. 7 to 9, annexed, which illustrate an "Atritor" installation in connection with two 140 ft. by 8 ft. rotary cement kilns. This hot air dries the coal, and it may be noted that coal containing 25 per cent. of moisture has been successfully dealt with by the machine. The coal which is carried into the machine by the cold air current meets the hot air current on the face of the rotor and is dried as it is broken up. The hot air current is regulated by a regulating lever shown at A in Fig. 1, and provided with a clamping screw B. The coal is broken by coming in contact with an intermeshing series of hard metal pegs. These can be seen in Fig. 6, and their general form and arrangement will be clearly understood from the views of the opened-out casing and the rotor which are given in Figs. 11 and 12. As the rotor revolves, the coal is caught between the various distributed pegs and is effectively pulverised. It is an essential feature of the "Atritor" that the coal goes through two different sets of pegs in its passage through the machine. Pegs are fixed on each wall of the casing and on each side of the rotor, and it will be clear that the coal in its traverse from the position M of Fig. 6 to the position N will receive two treatments. These treatments are known respectively as the "first effect" and the "second effect."

Fig. 9.



The pegs in the "first effect" are carried completely across the passage through which the coal travels as a result of centrifugal force and the draught caused by the fan, and as a consequence there is no possibility of any coal getting through without being broken. In the "second effect" through which the coal is drawn by the fan draught, the rings of pegs on the rotor are carried only half across the chamber, leaving a free passage at one side except for the presence of the stationary pegs fixed to the casing. The innermost ring of pegs on the rotor is, however, carried right across the chamber. This inner ring is composed of thin pegs which enter a recess in the casing on the other side. This ring acts as a rejector for coal particles which may still be too large for use and throws them back into the "second effect" where they are further broken up. The draught from the fan combined with the paddle effect of the pegs causes a set of eddy currents towards the centre on the side of the casing, and towards the periphery up the side of the rotor disc, with the result that a circulation is set up and the coal does not pass on until the particles are so small that they are drawn by the fan and propelled into the furnace.

The suction and blower fan is carried on the main rotor shaft, as will be seen from Fig. 6. This fan delivers to a scroll leading to the outlet to the kiln, as is best seen in Fig. 3. A ring with circular ports is carried on the face of the fan casing, as shown in Fig. 3. This ring regulates the opening of auxiliary cold-air ports. It is operated by the handle D of Fig. 2, and locked in position by the screw E. The full capacity of the machine is 1,800 lb. of coal an hour. For this output the slide under the coal hopper should be full open and the feed screw run at its highest speed, the auxiliary ports on the delivery side being kept closed. For a smaller output the coal supply slide is partially closed, and the air supply regulated until no coal is thrown out by the separator. For a still smaller output it is necessary to open the auxiliary air ports to give sufficient air for combustion. The machines may, of course, be driven in any convenient way. In the installation illustrated in Figs. 7 to 9 an individual motor drive is used for each pulveriser, while in the plant shown in Fig. 13, the machines are driven by belt from a line shaft. Each machine of this size takes about 30 h.p. when dealing with coal of a size not exceeding ¾ in. in any direction, but it is recommended that 40 h.p. motors should be installed. The machine is guaranteed to give an output of 1,800 lb. of coal an hour pulverised, from ¾-in. lumps to a fineness such that 95 per cent. will pass a British standard 100 by 100 mesh screen.

The first "Atritor" was put into commission at the Stockton works about twelve months ago, and since that time has been put to very complete practical tests. The cost of pulverisation by the "Atritor" at Stockton is about 2*s.* 7*d.* per ton, while by the old installation it was 5*s.* 3*d.* per ton. We understand that this latter figure was a very good one and that figures ranging from 6*s.* to 10*s.* 6*d.* per ton are common. It has also been found that a lower grade of coal can be successfully utilised since the installation of the "Atritor" pulverisers. The difference in cost between the lowest grade coal it was possible to utilise with the old plant and that which can be burned quite satisfactorily with the "Atritor," is from 10*s.* to 7*s.* 6*d.* per ton delivered at the works. A method of working which has been developed in connection with the plant and has been patented, lies in the addition of a small amount of paraffin to the coal during pulverisation. This is said to have a remarkable effect when using coal of poor quality. The amount of paraffin used is very small, 0·07 per cent. by weight, of the fuel burned, or about 1½ pints for 1,800 lb. of coal. In some cases the paraffin can be shut off when full heat is attained, but in the case of very inferior coal may be maintained during the whole of the firing period.

WIRELESS CONNECTION BETWEEN HOLLAND AND ITS COLONIES.—The question of establishing wireless connection between Holland and her Indian Colonies has been to the fore for some time, and preliminary tests have been going on for some four or five years. It was originally intended to use Honolulu as an intermediate station, but by adopting short waves and night service, direct connection proved obtainable, with comparatively little energy. A provisional station of 100 kw. was constructed, the power being supplied by an aeroplane motor. The antennæ were suspended between steel towers. This first station was subsequently improved, but has now been superseded by a larger one, which is now operating. This is a very powerful station, fitted with plant having an output up to 1,800 kw. Most of the plant has been imported from America. A smaller station has likewise been erected, which, however, cannot keep up continuous connection with Holland, but is used principally for the transmission of messages to Japan and China.

"SEMI-STEEL."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of June 30 you give, on pages 821 and 822, a report of the first day's proceedings at the annual conference in Birmingham of the Institution of British Foundrymen, and in which some prominence is given to the paper on "Semi-Steel," by Mr. J. Cameron and the discussion thereon. Several inaccuracies have crept into the report, which I, as one of the speakers referred to, should like to correct.

In the first place, Mr. Cameron is connected with the firm of Cameron and Roberton, of Kirkintilloch, and not the Carron Company, as is stated on page 821. On page 822 there appears the following: "Another speaker emphasised the point that the absorption of carbon by the steel took place mainly after the latter was fully melted. He had not been able to get more than 0·5 per cent. to 0·6 per cent. of carbon absorbed at the time of melting, *but with a low bed of a depth equal to 12 per cent. of the diameter of the cupola, the absorption was from 1·9 per cent. to 2 per cent. With a still lower bed 2·6 per cent. had been absorbed.*"

The last part, the italics are mine, is contradictory. What I did say was that the amount of carbon absorbed after fusion depended upon the depth of coke through which the metal passed, and the results of some recent experiments in a small cupola, showed that with a coke bed having a depth equal to 12 per cent. of the diameter of the cupola at the tuyere level the metal in the well contained between 1·9 per cent. and 2 per cent. of carbon, with *deeper* beds the amount absorbed was larger, as for instance, when it equalled 23 per cent. of the diameter, the carbon was 2·37 per cent., and with depths equal to 70 per cent. and 110 per cent. of the diameter the metal contained 2·60 per cent. and 2·76 per cent. of carbon respectively. It appeared that no further absorption took place with still deeper beds. These results indicate that steel melts quite easily in a properly-designed and managed cupola without necessarily becoming heavily carburised. These results would appear to confirm the statements in Mr. Fletcher's addendum that "Hot and rapid melting is necessary so that the steel does not carburise too rapidly in its descent through the cupola," and also that "the depth of well or hearth below the tuyeres should not be too great."

The report on page 822 suggests something totally different, and I shall be obliged if you will publish this correction.

I am, &c.,
A. CAMPION.

Falkirk, July 7, 1922.

THE FIRST STEP.

TO THE EDITOR OF ENGINEERING.

SIR,—I was rather surprised that the article on "The First Step" which appeared in the issue of June 2 should have been the subject of so little correspondence. May I, therefore, say something on this subject from the point of view of the "first-stepper."

It is generally recognised, I believe, that, after a course of technical training in an engineering college, a man should have about two years' workshop experience before proceeding to work in the drawing office or design department. It is the getting of this experience which seems to be the obstacle to the progress of the young would-be engineer. My own case is, perhaps, typical of a large number of others in the country. Eighty-three applications for a position in which I would gain experience brought me two offers. I accepted one, worked for six weeks and then had to leave owing to trade slackness. I am now working in a shop where I learn little and do a great deal of unskilled labourer's work.

My own experience, and that of several friends, seems to point to the fact that although employers are pleased to have men on their staff with a good technical education plus works experience, they are not at all willing to give us the chance of getting this experience under reasonable conditions. It is true that to employ a man straight from college is somewhat of a speculation, but, surely when a fellow can get a university degree in engineering at the age of 19—as many of us do—he is worth paying a wage of, say, 35*s.* to 40*s.* per week for a year or so. His employers would get their money back later on.

Finally, may I make a suggestion to the engineering firms in the country? Why not award scholarships in workshop practice, &c., to the students of the technical colleges? The "duds" would thus be weeded out, and employer, first-stepper, and nation would benefit thereby.

Yours faithfully,
LEONARD C. FREE, B.Sc.

2, Monktonhall Terrace, Musselburgh, Scotland,
July 11, 1922.

PREHEATING OF AIR FOR COMBUSTION.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the correspondence in your issues of June 2 and 23, on the loss sustained in boiler efficiency by the heat escaping in the flue gases, and the various remarks regarding the preheating of the furnace air supply to improve combustion. It is now, I think, generally recognised that preheating the furnace air supply is the fundamental basis from which both forced and induced draught systems have built up their success, because the great advantage derived from heating the air in order to consume the otherwise unburnt gases has, up to the present, been most obvious in these systems, especially as regards marine engineering.

It is as well, however, to bear in mind the fact that the advantages mentioned above can be materially lessened if an over-supply of air is introduced to the furnace resulting in the over-dilution of the gases, and consequently a less efficient combustion.

In Messrs. Howden and Co.'s letter they suggest that the ratio of the heat produced to the calorific value of the fuel depends upon the furnace design and conditions, and the efficiency by which that heat is transferred to the boiler. Taking the foregoing into consideration, and bearing in mind that in the majority of boiler houses very little room for making additions to the boiler plant is available, I have found that a system apart from the above, which is highly efficient in that it produces a high calorific value from the fuel for land installations, and at the same time effects a smokeless combustion is often more suitable.

In this system the air is induced through a specially-constructed pipe placed above the furnace and almost in contact with the crown plate. The air as it passes through this pipe becomes heated to an exceedingly high temperature, and is then discharged through a firebrick chamber having a perforated base in the form of a spray, the volume being regulated in conjunction with that admitted below the fire-bars for combustion to obtain, as far as it is possible, correct chemical action of the fuel.

The writer has taken tests of this appliance fitted to Lancashire boilers under natural draught conditions, and the results have been in every way entirely satisfactory. The appliance itself was examined after fifteen months' working and did not show any deterioration whatsoever.

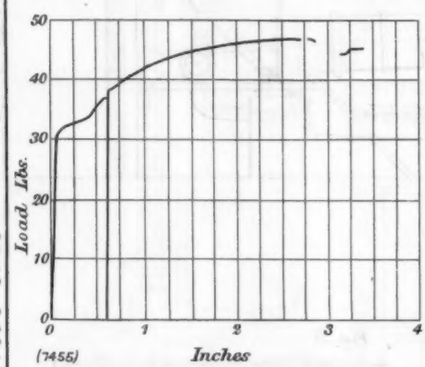
Yours faithfully,
A. ATKINS.

4, Trefoil-road, Wandsworth, London, S.W. 18.
July 10, 1922.

"THE ELASTIC LIMIT."

TO THE EDITOR OF ENGINEERING.

SIR,—I enclose a stress-strain diagram for iron wire, 0·0305 in. diameter by 10 in. long, which may be of interest to your correspondents. The load was taken



off after the elastic limit was reached and applied again with the result shown. Other tests of the same wire gave the elastic limit as 44,000 lb. per square inch, ultimate load 64,000 lb. per square inch.

I am, Sir, yours truly,
H. MUNRO.

Glasgow, July 3, 1922.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.—The negotiations between the Royal Institute of British Architects, the Surveyors' Institution, the Society of Architects, the National Federation of Building Trades' Employers, and the Institute of Builders, which have been proceeding for some time with a view to the preparation of a standard form of contract for building operations, have reached their final stage. A Drafting Committee has been appointed which is at work on the contract document. All matters on which the parties fail to reach an agreement will be referred to arbitration by a tribunal of appeal, consisting of one representative each of the builders and the architects, under the chairmanship of Sir William Mackenzie, K.C., President of the Industrial Court. It is hoped that the five spending departments of H.M. Government will accept the invitation extended to them to appoint representatives to assist the Drafting Committee.

HAULAGE SYSTEMS AND MACHINES IN UNITED STATES COAL MINES.—Statistics are published by the United States Bureau of Mines dealing with the haulage systems in use in the coal mines of that country. These statistics do not appear to be compiled from first-hand information, but as they thus receive the *imprimé* of the Bureau it is to be presumed that some degree of reliability may be supposed to attach to them. According to these figures, covering over 7,000 mines, electric haulage was reported in 3,274, the number of electric locomotives employed being 11,265. In 84 mines compressed air locomotives were used to the number of 212. Storage battery locomotives were employed in 693 mines, the number in use being 1,428. In 271 mines some 405 petrol locomotives were employed, while 528 mines reported together the use of 1,069 steam locomotives. As regards mining by machinery, 3,607 mines reported the use of 17,875 electric coal-cutting machines, while in 288 mines some 2,160 cutting machines, driven by compressed air, were reported to be in use. About 147 mines were using mechanical shovels for stripping overburden.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The latest returns of the principal engineering and armament works show that the past twelve months have been the worst on record, and that the firms concerned have had an extremely difficult task in retaining their commercial organisations at such a strength as will enable them to benefit from the current upward movement. Scarcely any new business has been done in armaments. Old contracts have expired, and there is little new business coming forward to engage this highly-specialised plant. A certain amount of work is on hand for British and foreign Governments, but it is only of a minor character, and the outlook in regard to armament work generally, particularly respecting the maintenance of expensive departments, is anything but cheerful. In the general engineering section conditions continue slowly to improve. The expansion in output following the settlement of the recent labour trouble has not been at the rate that was anticipated by the more optimistic traders. On the other hand, considerable numbers of semi-skilled and unskilled operatives continue to be absorbed at local works. Coupled with this is the fact that a heavier tonnage of pig-iron and hematite is coming into the district, showing that the finished sections are gradually getting into their stride, or, at any rate, into a more favourable position than they occupied before the engineering lock-out took place. Next week more steel furnaces will be in operation. The make is principally of soft basic material, for which there is a strong and growing demand. Prices are uniformly below those of Continental competitors, who are still in the local market for supplies of iron and steel scrap with which to feed their own furnaces. The scrap position, as was anticipated by local steel makers, has been rendered exceedingly difficult by the continued heavy demand from Germany. Six months ago there was a glut of this material, but to-day supplies are short, with the result that furnace masters are having to turn their attention more closely to pig-iron. In automobile and agricultural engineering, business shows signs of very slow but steady expansion. Rolling mills are receiving more orders from agricultural engineers in the Lincolnshire area, and there is a gradual rise in the demand for special steel and castings for automobiles. Textile and electrical engineers are well booked forward and have sound prospects. American users of special steels are organising stocks against the threatened rise in tariff rates. Russia is again in the market for tools and implements for her forestry and agricultural industries.

South Yorkshire Coal Trade.—Reduced production throughout the South Yorkshire area has caused values to stiffen. A strong inquiry is reported for large steams for export, though there is a bigger tonnage of South Yorkshire fuel at Hull than is necessary to meet the current demand. Business in industrial fuel is slowly improving. Slacks, smalls and nuts are not easy to obtain owing to the improved demand from engineering and power works. London is taking rather a larger tonnage of house coal now that prices are easier, but merchants are not entering into heavy commitments for forward delivery. Quotations:—Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 27*s.* to 28*s.* 6*d.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 22*s.*; Derbyshire small nuts, 16*s.* to 17*s.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

INSTITUTION OF CHEMICAL ENGINEERS.—A meeting of the Provisional Committee of this Institution was held on Wednesday, June 28. The secretary reported that the Board of Trade had referred to the solicitor certain points raised by the Institute of Chemistry in the proposed constitution of the Institution. The Institute suggested that misunderstanding would be avoided if the term "chemical engineer" were defined. After a considerable amount of discussion the following definition was agreed upon: "The chemical engineer is a professional man experienced in the design, construction and operation of plant in which materials undergo chemical or physical change." The further suggestion that the word "Institution" should be changed to that of "Association" was also discussed, and it was hoped that the Institute of Chemistry would withdraw their suggestion since the word "Institution" was definitely understood and placed the new body in its proper category. Application forms for membership can be obtained from the Secretary of the Institution, 166, Piccadilly, London, W. 1.

THE BELGIAN IRON INDUSTRY.—There are at present 22 blast furnaces in operation in Belgium, with a production per month of pig-iron averaging some 115,000 tons, that of steel being 90,000 tons to 100,000 tons per month. It is expected that these figures will improve, after many months of complete stagnation. Orders in hand will suffice for the first few months, and negotiations are proceeding for further orders. The general feeling is improving and prices are well maintained. The German competition on foreign markets has almost disappeared, except in the matter of heavy plates; the German industry is very busy with home orders of which, however, a large portion is really meant for Russia. For half-finished products and certain classes of rolled goods extensive German orders have been placed in Luxemburg, Lorraine and Belgium, and Germany is also a keen buyer of scrap, especially for blast and Martin furnaces. This naturally means that the prices for these commodities keep very high in Belgium, as German buyers are prepared to pay prices which are out of the question locally.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Ironmasters Committee have this week decided to discontinue fixing Cleveland pig-iron prices, and thus for the first time since February, 1916, there is an open market, and makers are at liberty to sell at whatever price they wish. The action, whilst not altogether unexpected, was very welcome. Customers now anticipate some fall in prices, though under existing conditions it is fully recognised that drastic cuts cannot be looked for, and for the present quotations remain in the neighbourhood of: No. 1 and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled, and white, 80*s.*—all f.o.t. makers' works or f.o.b. Tees.

Hematite.—Values of East Coast hematite tend easier, due to continued plentiful supply. Improvement, however, is anticipated. One or two more sales to South Wales are reported, and Continental inquiry is slightly better. Nos. 1, 2 and 3 are put at 94*s.* for home purposes, and at 92*s.* 6*d.* for export.

Foreign Ore.—There is very little doing in foreign ore, and values are still falling. As low as 25*s.* c.i.f. Tees is now named for best rubio.

Coke.—Coke keeps fairly firm. Few sellers name below 27*s.* for Durham average blast-furnace kind delivered, though local consumers are very loath to pay that figure.

Manufactured Iron and Steel.—General improvement in finished iron and steel is extremely slow. In one or two branches, however, there is rather more doing. Producers of railway material and of constructional work are better employed, but the dearth of orders in shipbuilding keeps certain departments slack. Competition for export business continues keen, and orders for abroad can be placed at substantially below the following rates, which rule for home trade:—Common iron bars, 12*l.*; iron rivets, 12*l.* 17*s.* 6*d.*; steel billets (soft), 7*l.* 15*s.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 10*l.*; heavy steel rails, 9*l.* 10*s.*; fishplates, 14*l.* 10*s.*; black sheets, 12*l.*; and corrugated galvanised sheets, 15*l.* 12*s.* 6*d.* to 15*l.* 17*s.* 6*d.*

Blast-furnacemen's Wages Reduced.—The average net selling price of No. 3 Cleveland pig-iron for the quarter ending June 30 last has been certified at 87*s.* 11·64*d.* per ton—a reduction of 6·36*d.* per ton, as compared with the realised price for the previous quarter, and under sliding scale arrangements this carries a reduction in North-East Coast blast-furnacemen's wages of 8·25 (8¼) per cent., thus lowering wages to 26·25 (26¼) per cent. above the standard.

Ironstone Miners' Wages.—A reduction of 5 per cent. in wages for the present quarter was agreed to at a joint conference of Cleveland ironstone mine owners and miners' representatives, held this week. On the ascertained selling price of pig-iron for the second quarter of the year being returned at 87*s.* 11·64*d.* per ton, a reduction of 15·1 per cent. in wages was claimed by the employers, but, after some discussion, 5 per cent. was agreed to.

THE SOCIETY OF ENGINEERS.—By kind permission of Messrs. Silvertown Lubricants, Limited, a visit has been arranged to their works at Minoco Wharf, West Silvertown, E. 16, on Monday, July 17, 1922, at 3 p.m.

TELEPHONE BETWEEN SWEDEN AND FINLAND.—The establishment of telephonic connection between Sweden and Finland seems now to have been decided on, the Swedish State telegraph defraying the expense of cables and the laying of them, half of the cost being debited to the Finnish Telegraph Department as a loan, calculated at about 30,000,000 F. marks for Finland's share. The cables are to be laid this autumn, proceeding from Abo (Finland) to Marieharun, and from there to Näskubben on the Swedish coast. The main cable is to contain six double lines.

GRANTS FOR WATER POWER SCHEMES IN GERMANY.—The *Deutsche Reichsanzeiger*, No. 125, of May 31, 1922, publishes laws sanctioning grants for various water power schemes in Germany. The first law sanctions a grant of 311,000,000 marks for the development of water power of the lower Fulda. This is a new scheme and provisions are made that the grant is either taken up by responsible ministers, or a company formed for the purpose. The State is allowed to issue bonds or bills, &c., to cover the amount sanctioned, and provisions are made for redemption of the bonds. The second law sanctions additional grants for the further development of the water power of the River Main. The sums originally granted were 6,200,000 marks in 1916, and 25,573,000 marks in 1920. The further sum now granted is 44,272,000 marks. As in the previous case the State is authorised to issue either bonds, Treasury notes, or bills, and provision is made for redemption. The third law sanctions further grants for the development of water power of the sources of the Weser. At the present time the sums already sanctioned are 10,500,000 marks in 1913 and 30,500,000 marks in 1920. The further grant sanctioned is 55,205,300 marks. Similar provisions are made as regards the issue of bonds, &c. The fourth law sanctions a grant of money (100,000,000 marks) for the purpose of ensuring the supply of water in the areas of the sources of the Weser and the Main, the grant to be made to responsible ministers, or a company formed for that purpose. Provisions are made as regards the issue of Treasury notes, bonds and bills, to cover the grant. It may be noted that the total amount of money sanctioned by the Prussian Government for the development of its water power is 510,477,300 marks.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Now that the holiday feeling prevails all round there is a greater reluctance than ever to enter into engagements, and consequently there has been little change in the position at the various Scottish steel works. The general trade of this country, as well as that of others, is not picking up very quickly from the recent slump, and consumers on all sides are moving very timidly and are not inclined to commit themselves to any extent meantime. The recovery is bound to be slow, but as the outlook is certainly much better, it is anticipated that a gradual expansion will take place when the holiday season is over. Meantime there is a better inquiry from abroad, but specifications are not very plentiful, particularly for ship plates. There has been a little more doing in structural sections over the week, but black sheets continue in very poor demand. The current prices are as follows:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 10*s.* per ton; sheets, ¼ in., 11*l.* 5*s.* per ton, all delivered f.o.b. Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable-iron trade a quiet tone still prevails, and the response to the recent reduction in price has been disappointing. A certain amount of booking has taken place and the outlook is better, but unless order books appreciate considerably very soon now, employment will not be much improved when the holidays are over. The price for "crown" bars for home delivery is 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig Iron Trade.—In the pig-iron trade of Scotland the improvement is very slow, but the very fact that some improvement has taken place is quite encouraging. The demand for hematite is nevertheless miserably poor owing to the lowly conditions prevailing at the steel works, but there is a fair outlet for foundry iron. To-day's prices are:—Scottish hematite iron, 5*l.* 8*s.* 9*d.* per ton at the steel works; foundry iron No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, both at makers' works.

REDUCTIONS IN RAILWAY RATES FOR GOODS TRAFFIC.—The Railway Clearing House announces that the English and Welsh railway companies have decided to reduce their charges on and from August 1 next. The reductions are a result of meetings held by general managers of the companies with representatives of trade and agriculture, organised by the Federation of British Industries. The rates of charges for merchandise traffic by goods trains will be 75 per cent. above the rates in operation on January 14, 1920, instead of 100 per cent. above such rates. Flat rate increases are to be reduced as follows:—1*s.* to 6*d.*, 9*d.* to 4*d.*, 6*d.* to 4*d.*, the 3*d.* flat rate is unaffected. The rate for smalls is reduced from 150 per cent. to 100 per cent. The settlement is not to affect the question of merchandise carried by passenger train, nor any present or future negotiations relating thereto.

HYDRO-ELECTRIC INSTRUCTIONAL COURSE.—The University of Grenoble arranges for a summer course of lectures on Hydro-Electric Installations and Power Transmission, and we have been requested by the Office National des Universités et Écoles Francaises, 50, Russell-square, London, W.C., to draw attention to the facilities thus afforded. The fee for the course is 110 francs, which, at the present rate of exchange is rather more than 2*l.* The course covers general considerations for the establishment of hydraulic power stations, preparatory work for obtaining power, central hydro-electric power stations, transmission of power, and distribution of energy. The neighbourhood of Grenoble affords facilities for the inspection of many very interesting examples of stations, and as the country is delightful the course may be recommended as a pleasant means of combining instruction with the enjoyments of a summer holiday.

BURNING OF 200,000 LB. OF PICRIC ACID.—The particulars of the fire which destroyed one of the picric acid sheds in the magazine of the Ordnance Reserve Depot at Sparta, Wisconsin, on September 28, 1921, are very curious, and they reflect the greatest credit on the courage of the soldiers on duty there (*Journal of Industrial and Engineering Chemistry*, June). Several disastrous explosions having occurred in the Eastern populous States after the war, picric acid was stored in Wisconsin in open sheds, provided with corrugated asbestos roofs. The sheds stand in the "pockets" of undulating sandy ground, the ridges of which are covered by grass and brushwood. The picric acid arrived there, moist with 10 per cent. of water, in wooden barrels; it was stacked three high in the sheds, and exposed to wind and weather. The summer heat dried the acid so that in one barrel on the south front the moisture was reduced to 0·6 per cent. at the top and to 2·9 per cent. at the bottom; some of the staves opened up, and some picric acid powder was split when the barrels were disturbed. On the day in question barrels were being removed from one shed when some hot carbon from the exhaust of the tractor set fire to the grass and to the loose acid; the whole shed was a mass of flames, 40 ft. high, and black smoke, before anything could be done, and another shed, 800 ft. away began to smoke. Volunteers there rolled the burning barrels out of the second shed and stifled the fire with the aid of sand and of chemical fire engines. The inward rush of air was so fierce that nobody engaged in the rescue work was seriously hurt by the fumes in spite of the minor explosions. Little more than the 200,000 lb. of picric acid in the first shed was destroyed.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—It is now practically certain that the threat of the South Wales miners to come out on strike at the end of the month in connection with the employment of non-unionists will not be put into operation. At a meeting of the Welsh Coal Board on Monday the matter was discussed, and the workmen's representatives decided to recommend the men not to tender notices pending a conference of the National Coal Board to be held in London on the 28th, to consider what steps can be taken to improve the position of colliery workmen. Exports of coal as cargo from South Wales in June amounted to 1,940,000 tons or 360,000 tons less than the quantity shipped in May. Newport was the only port to show any appreciable improvement in the volume of trade with a shipment of 409,500 tons compared with 367,300 tons in May. Exports from Cardiff were reduced from 1,510,900 tons to 1,184,900 tons, from Swansea from 269,500 tons to 216,200 tons, from Port Talbot from 126,600 tons to 98,500 tons, but at Llanelly they were increased from 30,800 tons to 31,600 tons. Shipments to France receded from 664,600 tons to 615,800 tons, to Italy from 345,000 tons to 290,400 tons, to South America from 386,700 tons to 308,200 tons, to Spain from 194,200 tons to 126,400 tons, to Portugal from 116,900 tons to 98,000 tons, to Greece from 19,100 tons to 14,800 tons, to British coaling depots from 279,700 tons to 125,900 tons, but to other countries was increased from 298,700 tons to 361,100 tons, mainly as the result of increased shipments to Germany, Holland, Belgium, Scandinavia and Russia. Meanwhile conditions in the coal trade have gone from bad to worse. Inquiries generally are extremely limited, and prices have fallen to the lowest levels touched this year. Even at these figures colliery salesmen are unable to secure sufficient business to keep the pits going regularly, and temporary stoppages in the coalfield are numerous through lack of trucks, caused by wagons being held up under load in consequence of the depression in trade. At several pits the men have had notice to terminate contracts, while it is seriously suggested by some owners that all the collieries should close down for a week so as to relieve the congestion existing on the railways as the result of so many trucks being held up by the lack of trade. So far as prices are concerned these are a matter of bargaining and dependent on individual circumstances. Nominally best Admiralty large is quoted at 24*s.* 6*d.*, but concessions can be secured on this figure, while best smalls by themselves are worth about 18*s.* 6*d.*, but taken in conjunction with large, buyers can secure a discount of 1*s.* to 1*s.* 6*d.* These values compare with 28*s.* 6*d.* and 19*s.* 6*d.* at the beginning of May and 24*s.* 6*d.* and 18*s.* respectively at the commencement of the year.

Iron and Steel Trades.—There is practically no change in the position of this market. Reports that the Burmah Oil Company had placed an important contract for tinplates has had no effect on prices which remain round 19*s.* 3*d.* for standard boxes. The abnormal fluctuations in Continental exchange rates have rather upset the export market, and for the moment the demand is inactive. In the past week 11,455 tons of iron and steel goods were shipped from South Wales of which 7,590 tons consisted of tinplates, 2,050 tons iron and steel, 910 tons galvanised sheets and 890 tons blackplates.

CZEKO-SLOVAKIAN IRON INDUSTRY.—The leading Czeko-Slovakian iron works have just formed a union, which has for its object to protect and advance common interests, there is to be a common sales centre, and general conditions of selling are to be agreed upon. Some 15 leading concerns in different branches of the iron industry joined at once.

Z-TRANSFORMATIONS OF IRON.—In trying to develop a new thermoelectric method of iron analysis, Professor G. Borelius and Mr. F. Gunneson, of the University of Lund, Sweden, observed some peculiar thermoelectric phenomena, which they describe as Z-transformations (*Annalen der Physik* 67, pages 227 to 253, May 17). Specimens, taken from the same iron, are heated to different temperatures, quenched in water, and the thermoelectric force of the specimen against an untreated specimen is then determined at ordinary temperature; the temperatures are so chosen in successive heat tests that the curves obtained cover the whole range 100 deg. up to 1,000 deg. C. These curves show, apart from the well-known A points, a series of the new Z-fluctuations. After experimenting with Lancashire iron and silicon iron, pure electrolytic iron prepared and fused in a vacuum furnace by Heræus, was tried. This iron gave a regular curve free of fluctuations of more than 0·01 microvolt, which would fall within the limits of experimental errors. The fluctuations became a little greater after the specimen had been heated in hydrogen gas (from which hot iron takes up very little hydrogen) and much greater (up to 1 microvolt) on heating the iron for 7 hours to 800 deg. C. In the curve of hydrogen iron Borelius distinguishes 12 Z-points within the range 100 deg. to 1,000 deg.; some of these points look as if they might be multiple. In other kinds of iron, similar, but not identical points were observed. The Z-points may be related to the jerky liberation of hydrogen, accompanied by heat generation, from heated iron at different temperatures observed by Roberts-Austen and later by A. Müller and Maurer. The quenching seems to be essential to the Z-effect, which appears to be due to the presence of certain impurities in iron, especially carbon and probably hydrogen (not silicon). Since even electrolytic iron is never free of traces of hydrogen, Borelius could not definitely decide whether or not the presence of hydrogen is alone sufficient to call forth the quenching and the Z-effects.

THE "ATRITOR" COAL-PULVERISING MACHINE.

CONSTRUCTED BY MESSRS. ALFRED HERBERT, LIMITED, ENGINEERS, COVENTRY.

(*For Description, see Page* 43.)

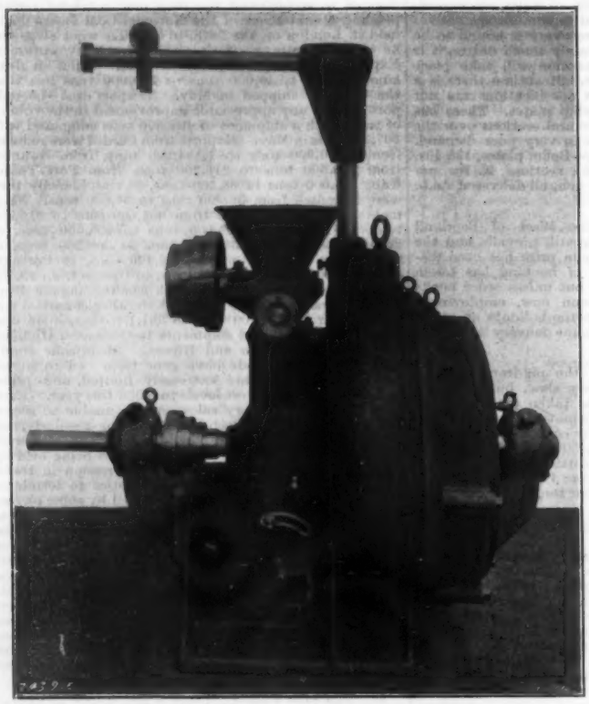


FIG. 10. GENERAL VIEW OF PULVERISER.

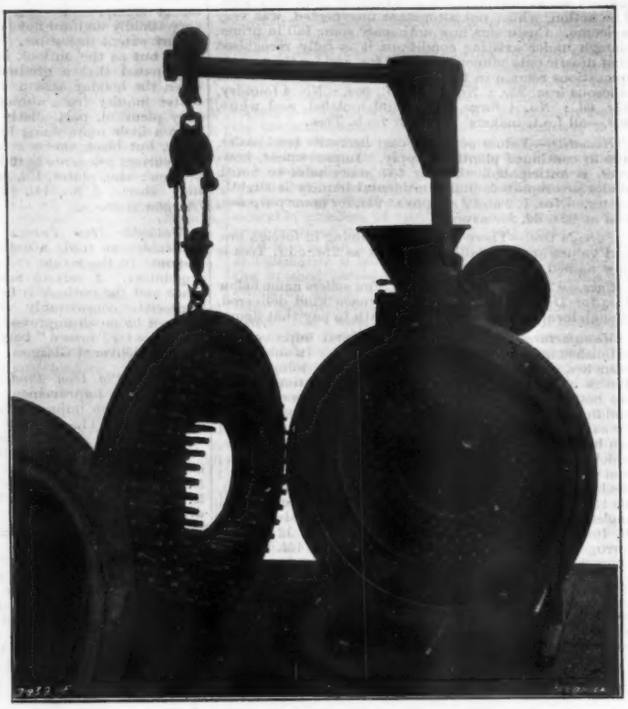


FIG. 11. PULVERISER OPENED OUT.

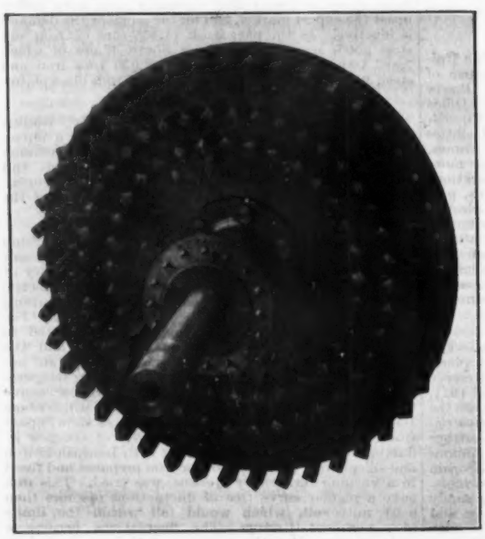


FIG. 12. THE ROTOR.

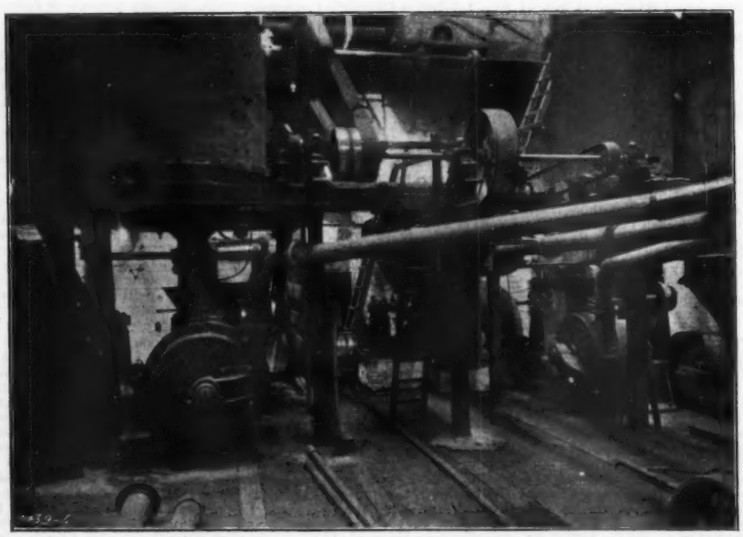


FIG. 13. INSTALLATION FOR CEMENT KILNS.

MANUFACTURE OF PIG-IRON IN NEW ZEALAND.—According to *The Dominion* (New Zealand), of May 4, the first tapping of the blast furnace at Onakaka took place on April 27. The report states that this furnace was erected by the Onakaka Iron and Steel Company, Limited, which was formed for the purpose of developing a part of the huge iron-ore deposits of Golden Bay. The company has installed a modern plant for the production of pig-iron; it has its own supplies of coal, iron ore, and limestone, and it is able to get the ore and the limestone in an open quarry cut not far from the furnace. The conditions are considered by experts to be exceptionally favourable. Several tons of pig-iron were run at the first tap. The furnace is now working very smoothly, no difficulties being encountered, and is tapped about every 8 hours. As the furnace settles down to work, about 8 tons to 10 tons of pig-iron per tap will be produced. The expert in charge is well satisfied, and says that the iron produced is all that could be desired, and is quite up to the high quality anticipated. It is the expressed intention of the company first to produce 100 tons to 150 tons of iron, which will thoroughly try out all the units connected with the plant. It will then close down temporarily, pending the completion of the coking ovens and railway of 1¼ miles to the wharf. With the completion of these units in a few months' time the linking up of all the necessary raw materials, iron ore, limestone, water and coal, with the works and the market will be complete. The furnace will then be permanently put into commission, and will run continuously day and night. The cost of raw material for the manufacture of iron at Onakaka, as compared with other countries, is given as follows: At Onakaka, per ton of iron at the furnace, including royalty, labour and freight, costs: Iron ore, 12*s.*; limestone, 3*s.*; coke, 40*s.*, total costs, 2*l.* 15*s.* Labour is not more than 15*s.* It is estimated that coal from the company's mine, when opened up, will not cost more than 15*s.*, including royalties, at the works. In England, as on February 1, the costs were about as follows: Iron ore, 2*l.* 11*s.*; coke, 1*l.* 6*s.*; limestone, 8*s.*, total, 4*l.* 5*s.* 6*d.*; this representing freight and cost of raw materials only.

55,000-H.P. TURBINE UNITS FOR THE QUEENSTON HYDRO-ELECTRIC PLANT, ONTARIO.

CONSTRUCTED BY THE I. P. MORRIS DEPARTMENT OF THE WILLIAM CRAMP AND SONS SHIP AND ENGINE BUILDING COMPANY, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 31.)

FIG. 18. A FINISHED RUNNER IN THE SHOPS.

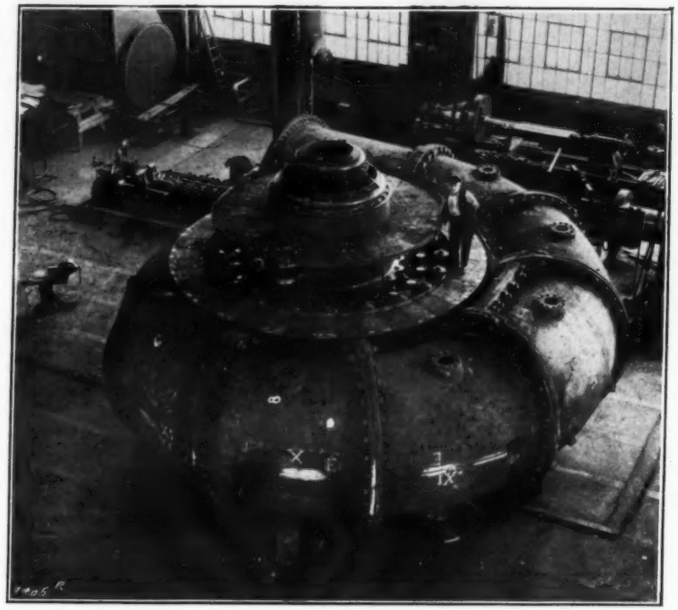


FIG. 19. A TURBINE ASSEMBLED IN THE SHOPS.

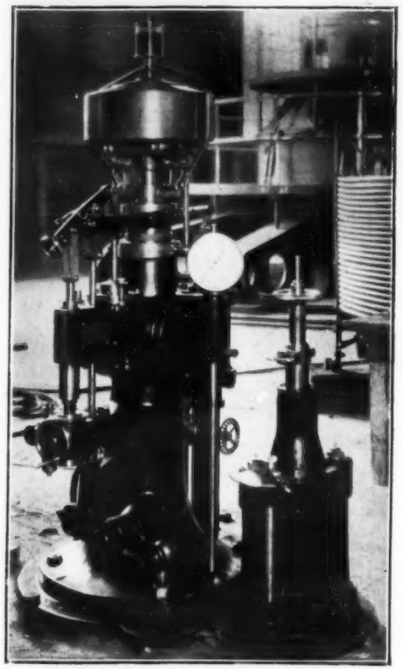
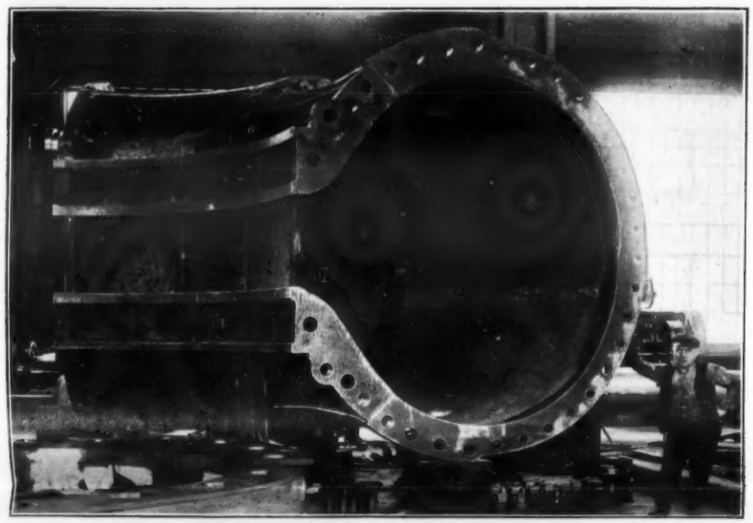


FIG. 20. TURBINE GOVERNOR.



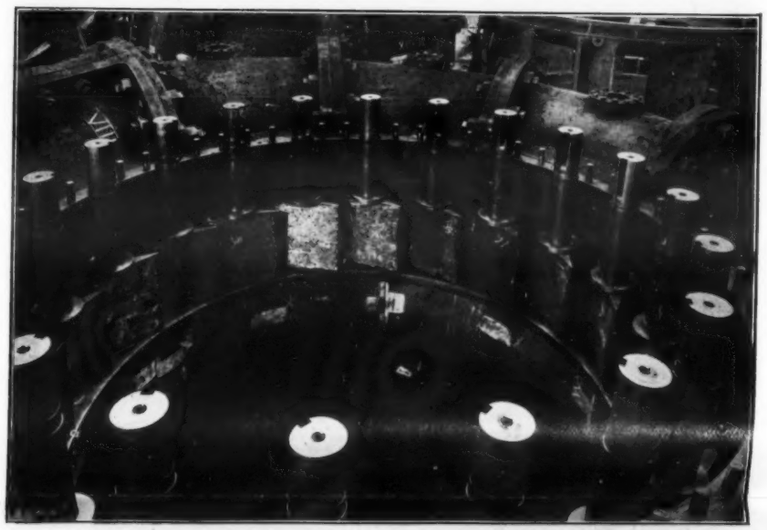


FIG. 21. SECTION OF THE BUILT-UP CASING.

FIG. 22. THE GUIDE VANES.

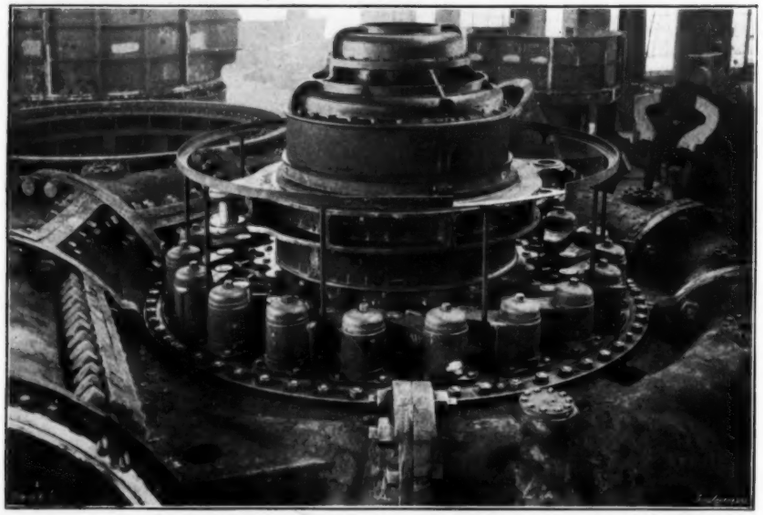


FIG. 23. VANE OPERATING GEAR.

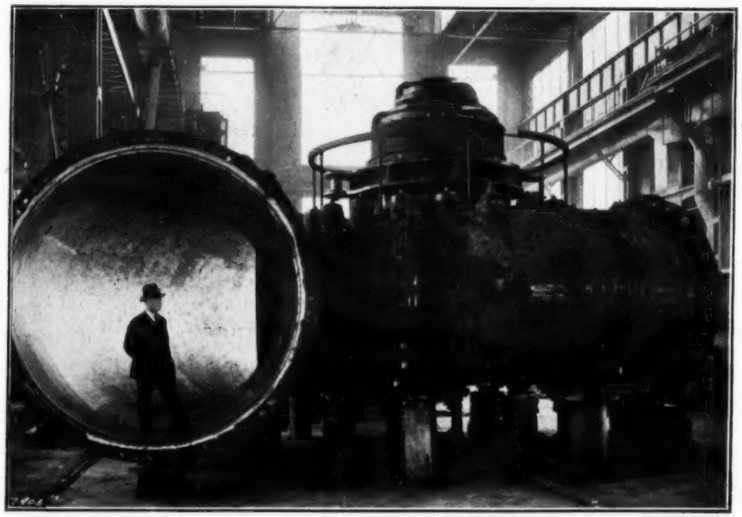


FIG. 24. TURBINE IN THE SHOPS, SHOWING SIZE OF INLET.

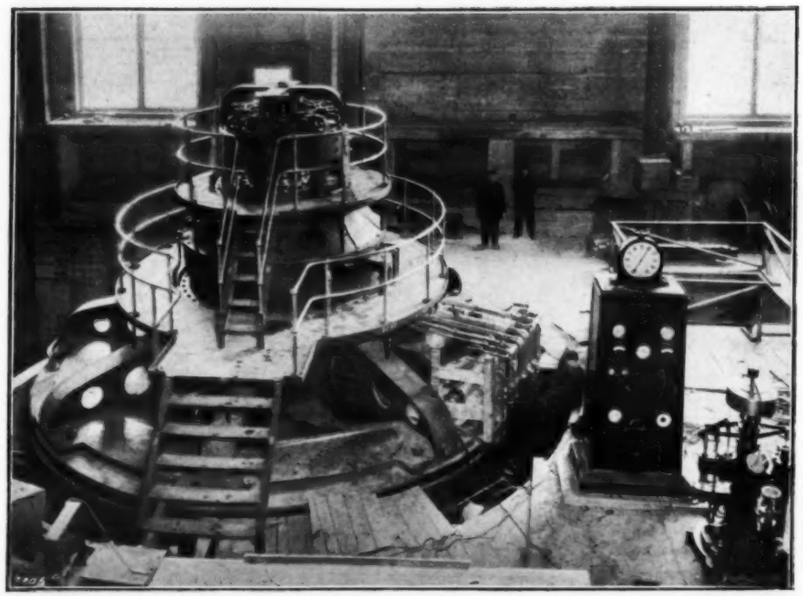


FIG. 25. A TURPINE IN POSITION AT QUEENSTON.

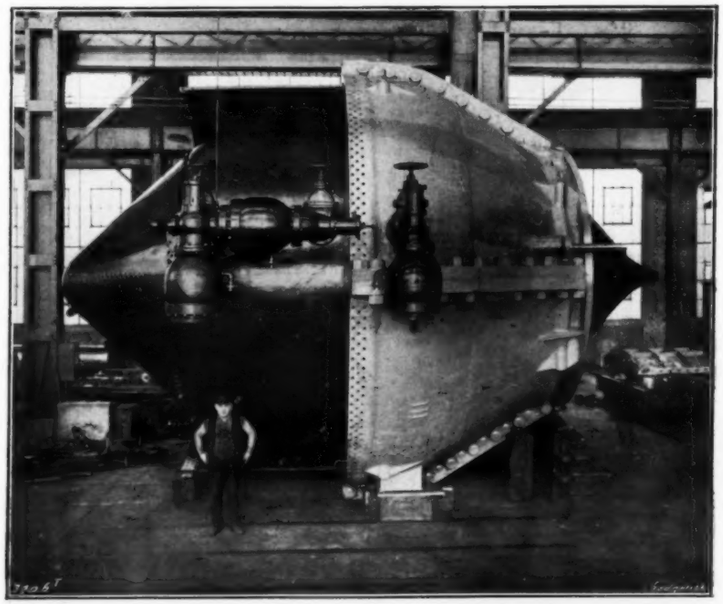


FIG. 26. 14-FT. JOHNSON VALVE BEING ASSEMBLED IN THE SHOPS.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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CONTENTS.

	PAGE
55,000-H.P. Turbines for the Queenston Power Station, Ontario (*Illus.*)	31
Choice of a System for Electric Traction on Main Line Railways (*Illus.*)	35
The Institution of Naval Architects	36
The Royal Agricultural Show at Cambridge (*Illus.*)	38
Industrial Notes	41
The "Atritor" Coal-Pulverising Machine (*Illus.*)	43
Letters to the Editor.—"Semi-Steel." The First Step. Preheating of Air for Combustion. "The Elastic Limit" (*Illus.*)	44
Notes from South Yorkshire	44
Notes from Cleveland and the Northern Counties	45
Notes from the North	45
Notes from the South-West	45
The Dissipation of Iron	47
The Shipbuilding Industry	48
The Physicist in Engineering Practice	48
Chemical Engineers' Conference at Glasgow	49
The National Physical Laboratory (*Illus.*)	51
Notes	52
Notes on New Books	53
Lorry Conversion Attachment at the Royal Agricultural Show, Cambridge (*Illus.*)	54
Saw Notching Machine with Automatic Feed (*Illus.*)	55
Stability of Large Ships (*Illus.*)	56
Testing Materials for Shipbuilding (*Illus.*)	57
Questions Regarding the Design and Action of Reduction Gears (*Illus.*)	58
Explosion of a Superheater	62
Catalogues	62

Two-Page Plate.—55,000-H.P. TURBINE UNITS FOR THE QUEENSTON HYDRO-ELECTRIC PLANT, ONTARIO.

ENGINEERING.

FRIDAY, JULY 14, 1922.

THE DISSIPATION OF IRON.

IN 1852, Lord Kelvin published the pioneering paper "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy." In this he showed for the first time that although the total amount of energy in the universe was apparently a constant quantity, its availability for the use and convenience of man was steadily diminishing. No doubt the dire results which may ensue on the exhaustion of our coal were realised long before Lord Kelvin's great generalisation was formed, but the subsequent development of electric methods of transmitting energy have rendered available new sources of power, and though it may prove necessary to transfer manufacturing industries to countries specially favoured by nature, mankind in general is little likely to suffer from a power famine for many generations to come, and recent researches afford at least some slight warrant for the hope that the eventuality may be indefinitely postponed.

Whilst there is thus a reasonable hope that civilisation may long evade being brought to a standstill by the dissipation of energy, there is at present less prospect of finding a remedy for the steady dissipation of iron in the form of rust, which has been estimated by Sir Robert Hadfield at 29,000,000 tons annually, which is not far removed from one quarter of the normal output. A pessimistic estimate of the world's resources, made by Professor Torneholm in 1905, placed the total visible supplies at 10,000,000,000 tons, whilst the world's output at the date in question was estimated at 100,000,000 tons annually and was increasing so rapidly as to lead him to fear an exhaustion of our resources by 1946. No doubt the above estimate of the world's resources was far too modest, but the supply of readily won and readily converted ores is undoubtedly limited, even although it is probable that the earth is in the main a mass of metalliferous iron. At present, however, the practicability of working this central core is even less conceivable than that of realising the beneficial use of the atomic stores of energy which Sir Ernest Rutherford has already successfully tapped, although on a truly infinitesimal scale. It is indeed conceivable that mankind may in the far future be driven to restrict the use of iron to special purposes such as the field magnets and armatures of electro-generating machinery motors, but long before such a policy becomes imperative, steps will have been taken to minimise the steady dissipation of iron and steel by rust.

The process of ferrous corrosion seems to be an extraordinarily complicated phenomenon and different observers have recorded most contradictory results. A comprehensive study of the whole question by Dr. J. N. Friend has just been published by the Iron and Steel Institute as one of the Carnegie Scholarship Memoirs, and is noteworthy not merely for the original work of the author but also for the exhaustive review of the work of previous investigators, and for the collection of many facts of great historical interest. Dr. Friend notes that as far back as 1840 Mallet, under the auspices of the British Association, made a magnificent series of researches on the relative corrodibilities of wrought iron and cast-iron. As is usually the case, however, with even the most careful and laborious experimental work, which does not result in any clear cut theory, these investigations were for the most part soon forgotten. Data, apparently contradictory, can in general only be assimulated as isolated facts based on actual personal experience, resembling thus the rules of thumb of the craftsman before the progress of science had established the *rationale* of many manufacturing operations. In the case of iron the experimental facts are remarkably erratic. Wrought iron for example is readily dissolved by ordinary sulphuric acid, but resists the fuming acid, and, as is well known, iron can be rendered "passive" by contact with strong nitric acid. Why, again, is iron rendered so brittle by the absorption of hydrogen, recovering its ductility when annealed or left for a sufficient time to stand in the dry? No wholly satisfactory explanation of these peculiarities seems yet to be forthcoming in spite of the very numerous researches made during the past 60 years. One of the first points to be established was that corrosion did not occur in the absence of an electrolyte. Iron exposed to the action of pure water does not rust nor does it rust in dry air, neither does it rust in moist air if the temperature is high enough to prevent deposit of the water on the surface. Dr. Friend, however, concludes that though an electrolyte is necessary another factor is also at work in the rusting of iron. His view is that when iron is brought into contact with air and liquid water, colloidal ferrous oxide is produced, which picks up further oxygen whilst still retaining the colloidal form. This higher colloidal oxide is, he considers, capable of catalytically accelerating the oxidation of the iron, whilst it simultaneously undergoes reduction to a lower colloidal hydroxide, and the cycle is thus repeated again and again, rust being produced when the colloid flocculates or precipitates out. According to this theory, the higher colloidal oxide acts as a catalyst and calalysts are, as is well known, capable of being "poisoned"; Dr. Friend's view accordingly receives confirmation from the fact that arsenious oxide is a powerful inhibitor of corrosion. Another peculiarity for which he is able to account is that iron exposed to the action of water (containing air) does not rust if the water is moving relatively to the iron at a speed of 3 miles to 5 miles an hour, whilst, in a similar experiment made with dilute acid, the attack increased with the speed of the fluid. In the former case Dr. Friend holds that the rapid motion removes the colloidal hydroxide which acted as a catalyst, and thus rusting is checked.

Amongst the interesting historical data collected by Dr. Friend are some valuable notes on the endurance of cast-iron when buried in the ground. Although for actuarial purposes it has been common to adopt a conventional life of 50 years, for cast-iron water mains it has long been known that this limit is in general far too low. Some of the gas mains broken in London streets by bombs during the German air raids had been down for well over 100 years and, apart from destruction by violence, appeared to be good for another century at least. Dr. Friend states that cast-iron pipes laid at Clermont Ferrand in 1748 were still in service in 1908; and five lines of cast-iron pipe, 1,000 ft. long, laid

in 1685 to convey water to the fountains at Versailles were reported in 1909 to be apparently in as good condition as when installed. On the other hand, in the case of the great main, 350 miles long, to Coolgardie, West Australia, it appears that the few castings employed have corroded very seriously, much more so than the wrought-steel pipes.

In sea water cast-iron resists badly, the iron being to a large extent dissolved out, leaving graphite behind. Thus, in 1836, cannon balls from the Mary Rose sunk off Portsmouth in 1545, were raised. Whilst maintaining their original dimensions the loss of iron had reduced the weight from 30 lb. to little more than 19 lb., whilst the "70-lb." shot weighed only 45 lb. When exposed to air these shot became red hot spontaneously and fell to pieces.

Possibly the future may see a great development of the adoption of the corrosion resisting alloys of iron of which a limited use is now being made. This, if commercially practicable, would certainly be the ideal solution of the problem of eliminating the present dissipation of iron by rust. In the meantime, however, reliance must be placed on paint and on prevention by electrolytic means. Dr. Friend has made a large number of experiments on the relative value of paints for this purpose. The maximum protection was found to be afforded by paints in which the proportion of oil was just sufficient to ensure smooth working properties under the brush. With ferric oxide as the pigment, and linseed oil as the vehicle, the best results were obtained with a 50-50 mixture, the weight applied being 7 to 9 lb. per 100 square yards. With thicker coatings the corrosion was greater.

THE SHIPBUILDING INDUSTRY.

IT is not particularly surprising, in view of the recent disputes in the engineering and shipbuilding industries, that the decline in the latter trade previously reported has been continued during the quarter just concluded. The statistics issued by Lloyds' Register show that the tonnage nominally under construction in this country has fallen from 2,235,998 at the end of March last to 1,919,504 on June 30, the reduction amounting to about 316,000 tons or, say, 14 per cent. As compared with the tonnage in hand at the end of June, 1921, viz., 3,530,047, the tonnage now building is less by 1,611,000 tons, or over 45 per cent. It must not be overlooked, moreover, that of the tonnage now classed as under construction, a considerable proportion, viz., 481,000 tons, is represented by ships on which work has been suspended for various causes, so that the tonnage on which work is actually proceeding at the present time is only about 1,439,000. This latter figure, it may be mentioned, is some 451,000 tons, or nearly 24 per cent. lower than the average for the twelve months immediately preceding the outbreak of war.

An even better index to the present position of the industry is given by the reduction which has to be recorded in the tonnages commenced and launched. During the last quarter, only 38,877 tons of shipping have been put in hand in this country, as compared with 51,008 tons commenced during the March quarter and with 69,028 tons started during the June quarter of 1921. The corresponding figures for the tonnages launched are 148,886 tons during the June quarter of this year, 334,352 tons during the March quarter and 321,690 tons during the June quarter of last year.

The vessels now classed as under construction in this country number 390, and, of these, 349, making 1,788,360 tons, are steamers, 32, making 129,134 tons, are motor ships, and only 9, with an aggregate tonnage of 2,010, are sailing vessels. The number of vessels now building which exceed 10,000 tons each is 37, and, of these, 4 come between 10,000 tons and 12,000 tons, 13 between 12,000 tons and 15,000 tons, 15 between 15,000 tons and 20,000 tons, and 4 between 20,000 tons and 25,000 tons; one other vessel exceeds 25,000 tons. Excluding vessels of less than 1,000 tons, it may be interesting to note that, of the ships nominally under construction in this country, 60, with a total tonnage of 383,221, are intended for the transport of oil in bulk; the tanker tonnage thus represents 20 per cent. of the shipbuilding work in hand in this country.

The reduction in tonnage under construction seems to be distributed fairly uniformly over the more important shipbuilding districts, the work at Glasgow, for instance, having declined from 602,702 tons at the end of March to 517,653 tons at the present time; for the other Clyde port of Greenock the figures are 185,956 tons for the March quarter and 162,693 tons for the June quarter. The tonnage now building on the Tyne amounts to 384,304, as compared with 438,154 tons three months ago, while the work in hand at Belfast has fallen off from 305,610 tons to 274,110 tons during the period under review. At Sunderland the decline has been from 181,457 tons to 144,301 tons. In order of magnitude the work now in hand at the remaining shipbuilding centres of the country is as follows: Middlesbrough, 75,124 tons; Liverpool, 62,120 tons; Dundee, 49,250 tons; Hartlepool, 46,530 tons; Southampton, 45,486 tons; Barrow, 42,448 tons; Hull, 34,124 tons; Leith, 20,320 tons; Newport (Mon.), 10,046 tons; Bristol, 9,408 tons; and Aberdeen, 5,985 tons.

The merchant tonnage building abroad has also declined during the quarter under consideration, the general position of the industry resembling that of this country. The total classed as under construction in the British Dominions and foreign countries on June 30 last amounted to 1,315,926 tons (476 ships), as compared with 1,443,624 tons (518 ships) at the end of the March quarter, and the difference of about 128,000 tons represents nearly 9 per cent. of the March total. Most countries are affected by the decrease, but this is particularly noticeable in the cases of France, Holland and Italy, the figures for which countries will be given later. In the case of the United States, a slight improvement has to be recorded in comparison with the March quarter, and Norway also has a greater tonnage in hand at the present time than she had in March. Of the total tonnage building abroad, work has been suspended on about 290,000 tons, or 22 per cent. of the total, so that the tonnage on which work is going on amounts to about 1,026,000.

The above-mentioned totals, however, do not include the tonnage building in Germany and at Dantzig, since exact statistics for these are not available. It is estimated that the tonnage building in Germany at the present time amounts to about 500,000, while at Dantzig the tonnage under construction is probably somewhere in the neighbourhood of 45,000. In June, 1914, the tonnage building in German shipyards, which then, of course, included those at Dantzig, amounted to 547,000, so that Germany has already practically recovered her pre-war position with regard to shipbuilding work.

Excluding Germany, the first position among the foreign shipbuilding nations is now held by Italy, where 88 ships, totalling 285,671 tons, are under construction; the tonnage building in that country however, has, declined from 311,888 during the quarter, and Italy is the country most affected by the suspension of shipbuilding work. In France, which takes the next place, 53 ships of 243,290 tons in the aggregate, are now on the way, as compared with 286,255 tons at the end of March, while in Holland, the tonnage building has declined from 258,240 to 226,318 (99 ships) during the quarter. As previously mentioned, the position of the American shipbuilding industry shows some improvement, the tonnage building having increased from 136,266 at the end of the March quarter to 150,623 tons (36 ships) at the present time; the last-mentioned figure is, however, only just over 20 per cent. of that for this time last year, which was 717,624 tons. Japan is now building 26 steamers totalling 115,512 tons, and the figures for the other countries having more than 10,000 tons of merchant shipping in hand are as follow: Norway, 53,403 tons (35 ships); Spain, 52,407 tons (12 ships); Denmark, 51,649 tons (23 ships); British Dominions, 49,960 tons (24 ships); Sweden, 40,475 tons (23 ships); and Belgium, 17,313 tons (7 ships). Of the figure given above for the British Dominions collectively, 21,447 tons is accounted for by Australia, 15,850 tons by Canada, and 9,910 tons by Hong Kong.

The total tonnage now building abroad, excepting that under construction in Germany which cannot be classified, includes 348 steamers making 1,165,525 tons, 71 motor ships of 122,194 tons in the aggregate, and 57 sailing vessels with a total tonnage of 28,207. If these figures be added to those already given for the United Kingdom, it will be seen that of the tonnage now building in the whole world, nearly 8 per cent. will be propelled in internal-combustion engines, and less than 1 per cent. by sails. The tankers under construction abroad number 22, and have an aggregate tonnage of 146,690, so that the total tanker tonnage now in hand, including that building in this country, amounts to 529,911 and represents over 16 per cent. of the whole of the merchant shipping now in course of production. The importance of this class of shipping is thus clearly shown.

We may remind our readers that in the shipbuilding returns compiled by Lloyds' Register, from which the above data have been extracted, gross tonnages are given in all cases, and also that the statistics take no account of vessels of less than 100 gross tons. It may also be of interest to mention, as evidence of the extent of the Society's activities, that of the total tonnage now under construction in all parts of the world, 2,010,912 tons, or 62 per cent., are under the inspection of Lloyd's surveyors with a view to classification in the Society's Register Book.

THE PHYSICIST IN ENGINEERING PRACTICE.

PHYSICISTS and chemists generally concede that the domains of their sciences have a common borderland. But they differ as to the boundaries. To some physicists, theoretical chemistry is really physical chemistry; others consider that little is gained by endeavouring to delineate the domains. Sir J. A. Ewing thinks it futile also to attempt to draw a line between physics and engineering; he would decline to serve on a boundary commission. Most engineers will agree with what he said on these questions when addressing the Institute of Physics last week on "The Physicist in Engineering Practice."

The first of these lectures had been delivered by Professor Archibald Barr, and was noticed in our issue of May 5 last, page 559. In this second lecture, when Sir Charles A. Parsons presided, Sir J. A. Ewing indicated three main ways in which the study of physics could profoundly influence the development of engineering. In the first place, he submitted, the knowledge of physics may determine the immediate creative work of the engineer, through the medium of inventions which may open up new avenues or merely concern minor features of design. Secondly, the physicist himself may make an advance in the principles of his own science of such a nature as to illuminate the operations of the engineer, by systematising what was haphazard by clarifying ideas and directing efforts, and by revealing possibilities and impossibilities. Sir Alfred showed that it is mainly by such steps that the study of engineering progresses, and under this heading fall in particular also the great services which physics renders to engineering by devising methods and instruments for exact testing. Sir Alfred's third alternative was rather too broad to stand out definitely. The progress of physics, he pointed out, had often affected the progress of engineering without intention of the discoverer and without recognition of the practical bearing of the discovery. The lecturer possibly hesitated to dwell on the practical value of pure research in addressing the Institute of Physics. But that really seemed to be his point, and his first exemplification, connecting the development of radiotelegraphy with Kelvin's prediction of the oscillary character of certain electric discharges, was hardly well chosen.

In his subsequent exposition, Sir Alfred took his illustrations mostly from the domain of thermodynamics, and it was curiously instructive to be reminded how ingeniously men like Carnot interpreted and correlated the phenomena of heat and force and yet failed to draw the—now—apparently so obvious final conclusion.

In 1765 James Watt introduced the separate condenser in order to keep the cylinder as hot as the steam that entered it, and to avoid the wasteful alternate heating and cooling of the cylinder in the early engines. His invention of the expansive

working was an equally great step towards making the engine reversible in the modern thermodynamic sense. He also invented the engine indicator, and, being in the first instance a physicist, he made independent discovery of the main facts underlying Joseph Black's doctrine of the latent heat. But Watt did not clearly recognise that the engine worked by taking in heat at a high level and rejecting it at a low level. In spite of the stir caused by Rumford's famous experiments on frictional heat (about 1800), the full significance of that drop in heat in the engine was not appreciated till 1824.

In his "Réflexions sur la Puissance Motrice" of 1824, Sadi Carnot dwelt on the need of a theory of the action of the heat engine which should be general and independent of the particular mechanism and the particular working substance. The steam, he stated, was only the means of transporting "Caloric" from regions of high temperature to regions of low temperature. He described a reversible cycle of operations, and proved that for the same supply of caloric no engine can do more work than an engine in which all the actions are reversible. He suggested even to improve the primitive internal combustion engine of the brothers Niepce, who had ignited combustible dust injected into a cylinder, by compressing the air and by making it pass into a closed combustion chamber together with a small amount of the combustible, and he indicated means of meeting the mechanical difficulties of such piston engines. Yet he still shared the current notion that the "caloric" passed through the engine without becoming altered in amount. In his posthumous notes, however—Carnot died in 1832, only 36 years of age—he clearly says: "Heat is nothing but motive power, motion which has altered its form. Wherever there is destruction of motive power, there is production of heat proportional to the power destroyed, and conversely."

But those notes remained unknown till 1878, by which time the doctrine so clearly formulated had become a commonplace of science. Clapeyron, engineer and mathematician, rescuing Carnot's "Réflexions" from oblivion, had in 1834 for the first time drawn ideal indicator diagrams with isothermal and adiabatic lines. But all the early steam users failed to understand that some heat disappeared in the cyclic process. Sir Alfred explained the reason. Only about 4 per cent. of the heat supplied to the engine was actually converted into work, and measurements of the heat supplied and of the heat discharged from the condenser would, allowing for heat losses, have differed by an amount that might well have been put down to errors of observation. Thus it happened that the consequences of the second law of thermodynamics: "a self-acting machine working in a cycle, unaided by external agency, cannot convey heat from a body at low temperature to one of higher temperature" (as formulated by Clausius in 1850), was discussed, before the first law of the conservation of energy was definitely recognised.

Experimenting since 1838, first with electromagnetic engines, driven by a galvanic battery, Joule had noticed that the heat, which would otherwise have appeared in the circuit, was diminished when the motor was doing work, and by 1843 he had found that the quantity of heat capable of raising the temperature of 1 lb. of water by 1 deg. Fahr. was equal to a mechanical force raising 838 lb. of water through 1 ft. When Joule presented a comprehensive statement of the doctrine of conservation, the essential indestructibility of all forms of what we now call energy, to the British Association at Oxford in 1847, he had to face very incredulous critics—though, we might add, the Heilbronn physicist and physician Julius Robert Mayer had already exposed the principle of the conservation of force in Liebig's "Annalen" of 1842. William Thomson was among the sceptics. If the capacity for producing work was lost when the heat was allowed to flow from the hot body to the cold surroundings, as Carnot had stated, how could Joule argue that heat, irrespective of temperature, was equal to work and might be converted into work? Thomson, then only 23 years old, did not rise during the discussion, however. He saw, he wrote later, that Joule had a great truth to bring forward, and he discussed the problem privately with Joule after the meeting. But Carnot's views and Joule's experiments still appeared incompatible to him in 1850, when Clausius at Bonn gave to the second law the expression we quoted above, basing his arguments upon the hypothetical properties of the perfect gas. In 1851 then Thomson made his thermodynamic arguments independent of the properties of any particular substance, and Rankine, whom Sir Alfred designated the third originator of the science of thermodynamics, proceeded again on other lines. Professor Callendar, Sir Alfred mentioned, had suggested that Carnot had really meant by his term "caloric," what we now call "entropy"; he did not himself share that view.

The practical engineer need not trouble whether entropy should be defined on the lines of Thomson's dissipation of energy, according to which the universe is in the state of a wound-up clock running down, or on the lines of Clausius, according to whom the entropy of the universe is tending to a maximum. But the engineer quite understands that, without the study of thermodynamics, no further improvement in the efficiency of engines can be hoped for, and that the development of the steam turbine, of the refrigerating and gas-liquifaction industries, and of the automobile and the aeroplane, would have been impossible, except by the co-operation of the theoretical physicist and the engineer. Progress often seems to have been slow. The heat interchanger or regenerator goes back to 1816, when the brothers Stirling constructed an engine which worked by the alternate heating and cooling of a confined amount of air. The regenerative steel furnace of the brothers Siemens came many decades later. In 1852 Kirk drove a Stirling air engine backward to serve as a heat pump. In the later ammonia refrigerators use was made of the throttling process and of the Youle-Thomson cooling effect. By forcing air through a porous plug Youle and Thomson had, in 1852, lowered the temperature of the air by $\frac{1}{4}$ deg. C. for a pressure drop of one atmosphere. Linde and Hampton subsequently made that effect cumulative. The most recent modifications of technical gas-liquefaction and separation machinery by Linde, Claude and others, are again the outcome of physical research, and, guided by theoretical considerations, Dewar and Kamerlingh Onnes have enabled us to approach the absolute zero of temperature within a few degrees.

The amazing achievements of automobiles and aeroplanes belong to the present century. But the late fashion to disparage the work of the Victorian giants, to which Sir Alfred Ewing referred in his conclusion, will doubtless be a passing fashion, as he himself said. "The present age is witnessing a wonderful efflorescence in physics; the older students are somewhat bewildered by the strangeness, the boldness, of the ideas simultaneously crowding in. I like to think that these new conceptions and discoveries will in time find their places in an ordered scheme, and in their turn will inspire the engineers whose business it is to administer the generations yet unborn."

In proposing a vote of thanks to the lecturer, Sir Napier Shaw made a very apposite remark. By further extending the principles of thermodynamics to that "extraordinarily complicated stuff, the atmosphere," somebody may some day enable us to understand the weather problems.

CHEMICAL ENGINEERS CONFERENCE AT GLASGOW.

THE forty-first annual meeting of the Society of Chemical Industry and the fifth conference of its constituent organisation, the Chemical Engineering Group, were held in Glasgow from the 4th to the 11th inst. inclusive. At each conference of the group a series of papers on related subjects provides a complete review of the development in a particular phase of chemical engineering. In former conferences the subjects of discussion were "Power Plant in Chemical Works," "The Transport and Distribution of Liquids," "Labour Saving Devices in Chemical Works," and "Filtration," and the volumes of proceedings form a comprehensive library on each subject. During the Glasgow Conference the papers read were on questions relating to evaporation and distillation. Professor Hinchley, of the Imperial College of Science and Technology, reviewed the general subject of evaporation, while the other papers read concerned the particular cases of tar and glycerine distillation and the design of ammoniacal liquor stills.

The opening meeting of the conference was held on Tuesday, July 4, in the Rankine Hall of the Institution of Engineers and Shipbuilders in Scotland. The Right Hon. the Lord Provost of Glasgow, Thomas Paxton, LL.D., welcomed the members to the city, congratulated them on the great progress the society had made since the last meeting in Glasgow in 1910, and expressed the hope that they would have a successful conference. Professor R. F. Ruttan, M.D., D.Sc., of Montreal, the president of the society, thanked the Provost for his words of welcome and said that no other city in Great Britain would be a more appropriate place for their society to meet in than Glasgow, with its eminent scientists, well-equipped colleges, gigantic industries and its progressive public institutions. After the formal business of an annual general meeting, Dr. Ruttan delivered his presidential address, the subject of which was "Some Aspects of Scientific and Industrial Research."

SOME ASPECTS OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

The president referred to the present general trend of scientific and general research, to the international organisation of science and to the post-war efforts of the Overseas Dominions to apply scientific methods to their industrial and economic problems. The general recognition of the value of co-operation was, he said, one of the best positive products of the war. Its impression on the organisation of science had been very prominent. Among the international movements resulting from this appreciation, he mentioned the formation of the International Research Council, established at Brussels in 1919, the second meeting of which will be held at the end of July. The council was composed of delegates nominated by the scientific national academies of the Allies, and the neutral nations, and affiliated with them were a number of unions representative of all branches of science, including the International Union of Pure and Applied Chemistry. It was, at present, little more than a nucleus around which the various scientific organisations might gather in the future. The council, he said, seemed to aim at the ultimate goal of making a world parliament of science. If properly developed, such an organisation should bring us nearer to the unification of mankind than any form of internationalism hitherto suggested, the underlying principle being the universalism of science and the catholicity of truth.

The establishment in Great Britain of an Advisory Council for Industrial and Scientific Research in 1915, and its subsequent organisation as a separate State Department had been quickly imitated by the other parts of the Empire. One of the principal activities of this department had been its co-operation with the industries of the country in founding and maintaining research associations, 29 of which had now been established. This indicated that the policy of industrial secrecy was now almost dead. The movement had spread to all the Overseas Dominions and to the United States, and the professor outlined the steps that had been taken in Australia, South Africa, New Zealand, India and Canada, and pointed out how these movements had revealed a dearth of sufficiently-trained men and of suitably-equipped laboratories for research. In referring to what had been done in Britain, Dr. Ruttan asked whether the present plan of State-aided research would provide for the future and whether the associations would, if the Government bonus were withdrawn, continue research on those problems which had no direct and immediate application to industries. The permanent success of all industry, especially the chemical industry, depended upon its ability to command a sufficient supply of knowledge, especially directed to improving the methods and products. A firm could not be expected to jeopardise its financial standing for the attainment of an academic ideal, nor could it consider the prosecution of fundamental researches

that might take five or ten years to have any effect upon a particular industry. The industrialist, as a rule, worked for the profits of to-day and not for the preservation of national wealth in the future. One of the first problems confronting the national research organisation of the Empire was the development of the association of the university men engaged in abstract science with those interested in its application. Universities should feel that they hold their laboratories and equipment in trust for the community.

Fear had been expressed that there was a growing tendency to exaggerate utilitarian motives in university investigation owing to the fact that fundamental research had to give place during the war to more urgent needs, but research in the abstract sciences and its applications were not incompatible and could often be organised in the same university with advantage to both. There was, however, a danger, especially in America, of the essential university function being less developed than this subsidiary function. The universities should be chiefly the training ground for research men, ample provision being made for graduate schools of research and training in the more abstract fields of science. University laboratory work was designed to inculcate those principles and habits of work which underlied all research. The high privilege of the universities was the preservation of real knowledge, not only to see that such knowledge once acquired was not lost, but also to extend its boundaries. The countries of the Empire expected capacity for research from the scientific departments of the universities. It was, therefore, essential that in any State system designed to develop the industrial research of a country, consideration should be paid to the needs of the universities in order to ensure a supply of men capable of conducting such investigations. A national research institute should be administered by a single responsible body, constituted, if possible, so as to encourage private benefaction, but with an assured endowment. The work of such an institute might well be confined to questions of basic importance to the nation and not directed to problems individual or incidental in their character. It is not unreasonable, Dr. Ruttan thought, for the industries to look to the State to conduct investigations in abstract science and on problems remote from immediate practical application, but possibly basic in the future production of national wealth. Scientific research should become an accepted responsibility of the State in a progressive democratic country, and the financial support of the abstract sciences, as well as of their material application should be as certain, as permanent and as free from party politics as a grant for national education.

Dr. Edward F. Armstrong, Warrington, the president-elect, said Dr. Ruttan had given them a clear picture of what was being done throughout the Empire to promote science, and he expressed the thanks of the members to the president for his inspiring address.

The members were entertained to luncheon by the Glasgow Section in the Grosvenor Restaurant, and in the afternoon they attended a garden party at The Knowe, Pollokshields, given by Mr. David Perry, a past chairman of the Scottish Section.

In the evening there was a reception and dance in the Municipal Buildings by the invitation of the Right Hon. The Lord Provost and magistrates of the City of Glasgow. Lord Provost Paxton welcomed the guests, and said it was gratifying to the corporation to receive the members of an institution which was exercising such a far-reaching influence upon humanity. He spoke of the problem of preserving an unpolluted and smoke-free atmosphere in large cities, and said he looked to the industrial chemists to find an effective solution.

The Messel Lecture.

The second day's proceedings were opened by the president with many references to the outstanding work of the late Dr. Rudolph Messel, an extremely enthusiastic and able member of the Society of Chemical Industry who, when he died, in 1920, left a bequest of 20,000*l.* to the society. The council decided to use part of the bequest for a series of lectures to be known as the "Messel Lectures," and to prepare a medal to be given by vote of council to the most distinguished chemist of the time in Britain. He presented the "Messel Medal" to Professor H. E. Armstrong, F.R.S., in recognition of his distinguished career as an educationalist and his outstanding work as a chemist and scientist.

Sir William Jackson Pope said that the fact that Professor Armstrong was an intimate friend of Dr. Messel of itself made the choice of the first medallist an appropriate one, but Professor Armstrong had many other qualifications. Just as Dr. Messel was a pioneer in technical chemistry, so Professor Armstrong was a pioneer in technical education. Great schemes for bringing scientific and technical education within the reach of everyone capable of benefiting by it, schemes which became realities forty years ago, were carried into execution by Professor Armstrong and a small band of similarly-minded enthusiasts. It was certain that such co-operation as now existed between chemical science and chemical technology in this Empire and in America originated in the great campaign for technical education that Professor Armstrong and his fellow enthusiasts initiated nearly half a century ago.

Professor Armstrong, in the course of his lecture on "Rhapsodies Culled from the Thionic Epos," paid a high tribute to Dr. Messel and his work. He said the claim, the right of chemistry to rank as fundamental, not only to other sciences but to all human activity, had yet to be made clear. "Think what the chemists could make of this drab town so needful of beauty, think what they could make of it if they had their way. At least they could get rid of its murky atmosphere." The chemist should be a critical, thoughtful and exact writer. To take rank in the world he must not only hold his own against the best of his competitors, but force his way ahead of them. To save the world from a Russian fate, science must be made as constructively effective in commanding human nature as it had been hitherto in hurrying the nations to their ultimate destruction. Free exchange of opinion and free criticism was much needed among chemists. It was time they fortified themselves and sought to deserve the title of scientific workers and thinkers. Human understanding was frail and limited, but not so limited as they made it appear. There was no conscious effort made by them to be impartial and logical, and their difficulties arose from lack of culture, from the gross specialisation of the day which was largely conditioned by their satanic system of competitive examinations; a system more calculated to kill genius could not possibly be devised.

Calibration of Storage Tanks.

After the Messel lecture, a paper was read by J. W. McDavid, D.Sc., F.I.C., on "A Rapid and Accurate Method for the Calibration of Storage Tanks." The lecturer referred to the methods usually employed for this work as being measurement of the vessel to determine its volume by mensuration or by filling the vessel with water and weighing the water as it ran out. Both methods were, it was thought, open to objections, the former because it was only accurate when the vessel was of some definite geometrical shape, and the second because of the labour it entailed. Another method sometimes used by chemists was to fill the tank with water in which a known amount of a soluble salt was later dissolved and, after stirring to make the liquid uniform in strength, analysing the solution. This method was a very neat one, but if the volume for each inch depth were required, the process became a very laborious one. The method described in the paper by Mr. McDavid depended on the principle that water flowing through a tube or orifice under a constant head had a constant rate of flow. This method, though fairly common in engineering laboratories, did not seem to have been used in chemical works. The lecturer suggested the use of a portable tank of 4 in. diameter, and a little over 2 ft. in length provided with an overflow outlet, such as was used in gas calorimeters, to ensure the maintenance of a constant head. Perforated plates in the vessel were useful in keeping the water conditions steady. The nozzle was situated at the foot of a pipe passing through the base of the tank. The nozzle fitting was provided with suitable threads to screw to the pipe and standard nozzles of different sizes could be used. The apparatus was provided with a plumb-bob to facilitate its erection in a vertical position. The plant could be calibrated by allowing it to pass water into a tank on a weighing machine. Once calibrated, the apparatus was available for use for any storage vessel, and it was provided with an iron tripod stand with levelling screws. A small funnel below the nozzle was provided to direct the water to the waste pipe before the actual calibration was commenced. The lecturer gave figures showing the volume of water delivered through each of the standard nozzles used with his measuring vessel under varying temperature conditions. Examples were given of calibration work already carried out with the use of this apparatus.

Professor Hinchley expressed the appreciation of the members for this contribution to the methods of dealing with what was sometimes a very difficult and laborious task.

The other paper read was by Dr. R. A. Joyner, whose subject was "The Viscosity of Cellulose in Cuprammonium Hydroxide."

Provan Chemical Works.

After lunch the party divided into two groups, one going by electric tram car to the Dalmarnock Electric Power Station and the other by char-a-bancs to the Provan Chemical Works of the Glasgow Corporation Gas Department. Great interest was shown in the visit to Provan works, the first municipal chemical works devoted to the treatment of coal-tar residuals.

The Glasgow Corporation have a chemical works at each of their four gas works, but three of these are only used for the crude distillation of tar. All the oils to be refined are transported in railway tank wagons to the Provan works. These have been completely reorganised during the last two years, and there have been extensive additions of plant, the erecting of which is now nearing completion. The steam plant installed consists of Babcock and Wilcox boilers with Underfeed stokers for burning coke breeze under forced draught. The sulphate of ammonia plant consists of two units, each capable of treating 70,000 gallons of ammonia liquor (1·5 per cent. NH_3) per day, equal to the production of 20 tons of sulphate of ammonia. A distinctive feature of the installation is that all the pumps are concentrated in the one house and they are all of the three-throw type. These pumps, the lime-mixers, the sulphate of ammonia, scraper conveyors, and the dryer, all receive their drives by belts from overhead line shafts. The tar plant consists of a block of four stills, each with separate preheaters and capable of distilling 200 tons of tar per day. There are two Wilton dehydration coils for the stripping of naphtha from light oils. The tar acid distillation plant consists of two 20-ton stills with fractionating columns packed with Lessing rings. An extensive benzol plant completes the equipment.

The Dalmarnock power station, which was visited by the rest of the party, was described quite recently in our columns. (See ENGINEERING, vol. cxi, pages 635, 703, 736 and 767, and vol. cxiii, page 682.)

The Annual Dinner.

The annual dinner was held in the Grosvenor Restaurant in the evening, Professor R. F. Ruttan, the president of the society, occupying the chair. There was a large attendance, including the Lord Provost and Mrs. Paxton, Sir W. J. Pope, F.R.S., Sir John Reid, Dr. H. F. Stockdale, Professor E. F. Armstrong, Professor H. E. Armstrong, Professor G. G. Henderson, Dr. Ellwood Hendrick, Mr. D. Perry, Mr. E. V. Evans, Mr. J. H. Young (the chairman of the Scottish Section), and Dr. John A. Cranston.

Dr. E. F. Armstrong proposed the toast of "The Society of Chemical Industry." He felt bound to refute the suggestion sometimes heard that we had not, in this country, technical ability and aptitude both to invent and carry out chemical operations. We have, in this country, the aptitude and ability to invent and carry out any process under the sun, and we do not want to import, introduce, smuggle or convey under any Acts of Parliament, under any definition, with or without duty of any kind,

foreign chemists, foreign ideas or foreign brains into this country.

The Chairman, replying to the toast, said the society was in a remarkably good state. The branches in Canada were also in a flourishing condition. He agreed with Dr. Armstrong as to the importance of bringing chemistry more actively and clearly before the public, so that they would know what chemistry was, what it had done, and what it could do. That could only be brought about by proper publicity. He suggested that renewed efforts should be made to emancipate the chemists in the universities of the Empire from the domination of German reference books. The almost exclusive use of German chemical compendia and monographs throughout the whole civilised world had given that country a world-wide influence and prestige out of all proportion to the value of its contributions to knowledge. He urged the value of an intimate connection between the scientific branches of the universities in the Overseas Dominions and those in Great Britain. They hoped that conditions would be such that their students would be induced to come here to complete their courses.

Sir W. J. Pope, F.R.S., in a humorous speech, proposed the toast of "The City of Glasgow," to which the Lord Provost suitably replied.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

(Continued from page 9.)

IN proceeding with our comments on the work of the Laboratory we pass to the Aerodynamics Department (Mr. R. V. Southwell, M.A., superintendent; Messrs. E. T. Relf, principal assistant, A. Fage, J. L. Nayler, L. W. Bryant, and T. Lavender.)

Aerodynamics. Wind Channels. Roof Balances.—The duplex 7-ft. wind channel, described last year (ENGINEERING, July 15, 1921, page 98), is now completed, and the two fans (11½ ft. diameter driven at 1,400 r.p.m.) and Mr. Hyde's cellular wall, together with the Ward-Leonard control of the two 200-h.p. motors, give the desired uniformity of air velocity (the maximum being 110 ft. per second, or 85 miles per hour) and direction within 0·5 per cent. The principle of Mr. Relf's roof balances has also been explained. Those for the single and the duplex channels, however, differ in some important particulars, the lift balance of the duplex channel being arranged to measure either the sum or the difference of the tensions in the suspension wires, so as to give both the lift and the rolling moment on the model.

Air Screws. Pressure Distribution. Aerofoils.—The apparatus for testing air screws is illustrated in Figs. 1 and 2. The motor driving the screw is supported by the four wires W, the upper ends of which have points fitting into hardened steel cups on the hooks H, so that the motor is free to move longitudinally; the points P fit into similar cups of the Y-pieces at the lower ends of the wires; a torque applied to the motor thus tends to rotate it about P P. The attachment to the channel balance is by means of three rollers on point bearings fitted to the lower end of the stem S which is attached to the motor casing; the axes of two of the rollers are at right angles to the motor axis, to which the third axis is parallel; the air screw torque can hence be measured on the cross-wind force-arm of the main balance, and the thrust on the drag arm. The revolution counter R rings a bell every 100 revolutions. The motor current is supplied through mercury cups.

As regards the pressure distribution over the surfaces of rotating air screw blades, measurements have been made over the median sections of six square-ended aerofoils of aspect ratio 6 (with section similar to air screw blades). They are mounted with their ends adjoining two parallel plates in order to eliminate end effects when determining the effect of aspect ratio on the air flow at the median section. To obtain further correlation between aerofoils of aspect ratio 6 and the corresponding sections in the air screw blade, pressure plotting was carried out on a special aerofoil of the same shape as the air screw blade, but without twist. For these measurements a series of fine tubes, about 1 mm. in diameter, is placed in longitudinal grooves on the upper surface of the foil; the tubes have perforations on the top and are separately joined to a multiple pressure gauge, which indicates the positive or negative pressure at the respective hole, holes not wanted momentarily being sealed. A beginning has also been made with testing a family of 24 air screws, all 3 ft. diameter and of similar blade

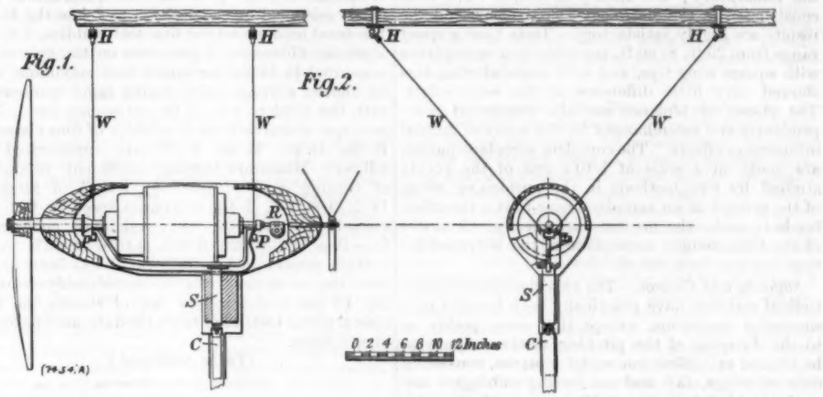


FIG. 3.

section, but varying as to width, number of blades and pitch diameter radio. The blades are detachable, so that tests can be carried out with two, three, four or six blades. All the air screws have been tested as tractors with various combinations of blades in front of the smallest possible body, while the body interference is studied by using three other tractor bodies of different sizes. In the further tests the air screws are mounted as pushers behind the various bodies, and the effect of varying the pitch (by rotating the boss) is being investigated; aerofoils are subjected to similar experiments.

In ordinary practice the machine and the air screw have to be tested separately. On the inspection day, a small 1 h.p. alternating-current motor of special design was also shown, which fits into the body of a large aeroplane model, so that these tests can be combined in the duplex channel. There were also demonstrations of apparatus used for determining all the three component forces and moments on a complete model of a flying boat. There was further on view a channel model, about 10 ft. in length, 1 ft. square, made of wood, which is bodily to be put into Dr. Stanton's boiler (mentioned last week) in which a pressure of 100 lb. can be maintained, for the purpose of making measurements of lift and drag in highly-compressed air and to study the change of $v\,l/\nu$, where ν is the kinematic viscosity. Mr. T. H. Fewster has designed a special balance for these experiments.

Yaw-Meter.—In the study of the air flow in the duplex channel, use is made of several novel appliances. The one new manometer is simply a U-tube, the one cup of which is fixed, whilst the other can be raised or lowered on an accurately-cut screw thread; as in the Chattock manometer the meniscus between water and castor oil is observed; the cup diameter is only 1 in., but readings to 0·001 in. can be taken, and the sensitivity is ample.

The new null-reading Wind Direction and Speed Meter of Mr. Bryant consists of five hypodermic speed tubes arranged symmetrically about a hollow cone the apex of which points into the wind. Four of the tubes, for yaw and pitch measurements, are bent so that their open ends form Pitot tubes inclined at 45 deg. to the cone axis, one pair being in each of two planes at right angles to each other. Together with the spindle, about 6 in. long, carrying the fine tubes, this part of the instrument looks like a slender foot ending in fine claws (Fig. 3). The spindle is mounted on a turntable fixed to the wall or floor of the wind channel. When taking a reading the instrument is turned so that there are equal pressures at the mouths of each pair of opposite tubes; the axis of the instrument is then along the wind. The fifth hypodermic tube has its open end well within the hollow cone; it registers the suction which is proportional to the square of the wind speed. When the axis of the instrument is along the wind, the diversion of which can be measured within 0·1 deg. of arc, the wind speed can be deduced from the pressure difference between the air in any of the four outside tubes and that in the suction tube. With the aid of the turntable the angle is determined through which the head has been turned when the yaw pair registers a zero reading. The instrument can further be turned about an axis joining the two yaw tubes, by means of a rack cut on a circular arc, which is rigidly attached to the tubes coming from the head; this is operated by a pinion connected to the fixed base and the sector, which is grooved to guide the circular rack-piece. The centre of the arc is a point equidistant from each of the openings of the yaw and pitch tubes; thus the head can be turned to point into the wind without shifting its position in space. The pinion is operated from outside by the aid of an inclined rod.

International Trials. Complete Aeroplanes. Aerofoils.—The Aeronautical Research Committee has

approached the aerodynamic laboratories of several other countries with a proposal to test a standard model aerofoil (R.A.F. 15 section: 6-in. chord by 36-in. span), and two model airship envelopes of different fineness ratios in as many wind tunnels as possible, in order to determine the characteristics of wind tunnels of different designs and the agreement to be expected between the aerodynamical data obtained in different countries. The model aerofoil has been tested in all the wind channels of the Laboratory; the airship envelopes have been constructed in the Metrology Department, and the results are highly satisfactory. Tests over a speed range from 20 ft. to 80 ft. per second on monoplanes with square wing tips, and with rounded wing tips showed very little difference in the scale effect. The planes of biplanes are also supported independently and interchanged for the study of mutual interference effects. The complete aeroplane models are made on a scale of 1/10; one of the points studied by two methods is the cushioning effect of the ground on an aeroplane near to it; the effect tends to make the machine nose-heavy. A model of the Dreadnought monoplane of the Woyevodsky type has also been tested.

Stability and Control.—The experiments on longitudinal stability have practically been brought to a successful conclusion, except that some points as to the damping of the pitching motion require to be cleared up. Skeleton model biplanes, consisting only of wings, tail and connecting outriggers are used in this connection. The systematic investigations of lateral stability is one of the principal items on the programme. The four principal derivatives, viz., the damping of the rolling and the yawing oscillations, the rolling couple due to unit angular velocity in yaw, and the yawing couple due to unit angular velocity in roll, have been measured at angles between 0 deg. and 16 deg. incidence of the main planes. This range covers stability in normal flight. At angles above the critical, complications occur.

In order to improve the lateral control of aeroplanes near the stalling speed the yawing and rolling moments due to aileron moments were determined for a representative machine up to large angles of incidence; the model was mounted with span vertical on points supported from a turntable which could be rotated to vary the angle of incidence. The experiments showed a large increase in the yawing moment due to ailerons in the neighbourhood of the stalling speed, and a corresponding decrease in the rolling moment, and this agrees with tests of a Bristol Fighter made in the Royal Aircraft Establishment. In the endeavours to secure adequate control at low speeds one of the greatest difficulties to be contended with is the tendency of the stalled aeroplane to fall into a spin. To investigate the nature of the commencement of this spinning motion Mr. Relf mounts a model aeroplane so that it can be continuously rotated, at speeds of from 1 to 10 turns per minute, by a small electric motor about an axis parallel to the wind direction. The whole apparatus is suspended by wires in the wind tunnel, and the torque produced by the action of the wind on the rotating model is measured by a balance. By studying the variation of this torque with speed of rotation in various types of wing formation it is hoped the tendency to spin will be eliminated without sacrificing efficiency from the point of view of ordinary flight.

Towing Aeroplanes. Aeroplane Carrier Ships. Airships.—One of the problems of controlled motion is the possibility of towing an aeroplane from an airship with the engine shut off. Calculations and experiments show that during flight longitudinal stability is preserved provided the aeroplane be maintained at a small negative incidence to the wind, and that the point of attachment of the cable to the aeroplane be in, or near to the, vertical plane passing through the centre of gravity; otherwise catastrophes may occur. Negative incidence means that the chord of the wing is inclined to the wind in the opposite direction to that which would produce maximum lift. Mr. Bryant has been comparing measurements made on the model of H.M. Aircraft Carrier Eagle with air-flow measurements on the actual ship to study the behaviour of aeroplanes landing on deck. The upper structure of the carrier should be such that the air near the flying-on deck is, so far as possible, not disturbed by yaw of the wind relative to the ship; even steady natural winds vary in direction, and the ship cannot therefore, be accurately steered into the wind. Many other features have necessarily to be taken into consideration in designing the ideal landing deck.

The full-scale airship experiments, pressures on pins and control surfaces, turning trials, &c., are completed for the present; the programme was partly curtailed by the decision to delete the R. 32. The total pressure on the fins and rudders, *i.e.*, the algebraic difference of pressures on the two sides, amounted to 18 lb. per square foot maximum, and its highest average value during rapid manœuvres with the rudders was 15 lb. per square foot. The principal characteristics of airships of four classes—R. 26, R. 29, R. 32, R. 33—are summarised as follows: Maximum turning coefficient (diameter of turning circle divided by length of airship), 11·2, 9·8, 7·5, 6·4; maximum speed in feet per second, 70, 79, 102, 88; resistance coefficient, $C = R/\rho V^2 l^2$, 0·025, 0·023, 0·0187, 0·017.

With respect to kite balloons it has been found that the total drag can be considerably reduced (by 18 per cent.) by the use of stream-line fins (metal plates instead of fabric) and stream line forms of envelopes.

(To be continued.)

NOTES.

International Regulations for Aerial Navigation.

An important Commission is now sitting in Paris to consider various international questions in connection with aerial navigation. The meeting, which commenced on Tuesday last and will probably terminate to-morrow, has been convened by the French Government in accordance with the terms of the International Convention for the Regulation of Aerial Navigation which came into force on the 11th inst. Lord. Gorell is acting as the representative for Great Britain and the British Dominions at the first meeting, and Major General Sir W. Sefton Brancker, who is also present, has been appointed the permanent representative for the whole of the British Empire, with the possible exception of Canada. The duties of the Commission are to receive proposals from, or to make proposals to, any of the contracting States for the amendment of the present Convention, and to carry out certain duties imposed upon it by the Convention. It has also to collect and communicate to the contracting States information concerning international aerial navigation, wireless telegraphy, meteorology and medical science as applied to air navigation, as well as to ensure the publication of aerial maps and to give an opinion on questions submitted for examination by any of the States. The Commission will be a permanent institution and will assemble three times a year, not necessarily in Paris, although it has been decided that, for the time being, the secretariat shall be established in Paris. London may be the place of the next meeting, but a decision on this point will probably be made at the end of the present meeting.

Automatic Train Control in the United States.

In a recent article* on train control we had occasion to refer to the situation as it existed in the United States. We find that as we actually went to press affairs had been carried by the Interstate Commerce Commission a stage further than we recorded. The most recent mail has brought us the report of the Commission on the appeal against its order of January last, which required 49 railroads of the United States each to select an approved train control system and to equip with it a complete specified passenger division, before July, 1924. The Commission has now issued a new order which is virtually a repetition of the former, with the alteration merely of the date, which is changed from July, 1924, to January 1, 1925. The railroads are now ordered to file plans for the installation of these systems by the beginning of next year, and from July 1 this year are ordered to report monthly what steps they are taking to investigate and test suitable systems in the next six months which are allowed by the Commission for this purpose. It is considered by the Commission that "within that period, provided a sufficient installation is made, and intensive tests of the device are conducted, it can be determined whether or not the device will be suitable." The Commission appears to base its argument on a detailed investigation of three systems in use on three railways to the extent of about 149 route miles, and the possible savings which may result from reduced compensation payments necessitated by accidents. The Commission's order covers over 10,000 miles of track and 5,000 locomotives. We sincerely hope that nothing of so wholesale an order will be expected here, and that if the adoption of train control should be deemed advisable much more than six months will be allowed for consideration, selection and preliminary trial of devices. Otherwise the railways will be involved in a good deal of waste. As a matter of fact we do not believe that, judged from the losses involved, the introduction of train control here is at all necessary. In the case of the United States the losses quoted by the Interstate Commission are certainly large, but they are so fragmentary as to be of little value. Figures for a few impressive cases do not lend much weight to the argument—what one wants to know is the total cost of accidents over a term of years compared with traffic, and if possible with the cost of preventive systems. In these matters the report of the committee of our Ministry of Transport is far more complete than the arguments made by the Interstate Commission, which body appears to be intent on asserting its authority by rushing the railways into the premature equipment of what is held to be an unnecessarily larger amount of railway mileage. The Commission has the power of ordering such installation under the Transportation Act of 1920.

* Engineering, vol. cxiii, page 819.

The Euston and Watford Electric Railway.

The commencement of services of electric trains between Euston and Watford and Broad-street and Watford on Monday last, marks the completion of the programme of suburban line electrification for which the London and North Western Railway Company obtained powers as far back as 1907. This programme included the electrification of the line between Willesden Junction and Earl's Court, opened for traffic towards the end of 1915, the electrification of the whole of the North London Railway from Broad-street to Kew Bridge and Richmond, opened in January, 1916, as well as the electrification of the Watford line of which the part between Queen's Park and Watford, forming an extension to the Bakerloo Tube, has been in operation since the spring of 1917. The two new services above referred to, have been rendered possible by the completion of extensive track work on the main line between Queen's Park and Euston and a branch through Chalk Farm connecting South Hamptead on the main line with Camden Town on the North London line. This work, which was entirely suspended during the war, was resumed some two years ago and has involved a complete rearrangement of the tracks at Chalk Farm, the construction of tunnels to take the electric lines under the main lines, and the construction of a tunnel for electric lines under Primrose-hill; all crossing of tracks at the same level has been avoided by these means. It should also be mentioned that a tunnel line, operated by steam, has been constructed from a point north of Chalk Farm station, under the main line and up at the far side to facilitate the movement of empty carriages into, or out of, Euston station. Power for the London and North Western Railway Company's electric lines is supplied from a generating station at Stonebridge Park, situated close to the line between Harlesden and Wembley. At present, it contains four 5,000 kw. Westinghouse-Siemens turbo-generators, supplied with steam at 205 lb. per sq. in. and 200° F. superheat by 20 Babcock and Wilcox land-type boilers, each having a normal evaporative capacity of 25,000 lb. per hour. Three-phase 25-cycle current is supplied at 11,000 volts to 11 sub-stations located at

different points on the system, one being situated in the power house. By means of static transformers and rotary converters in the sub-stations, direct current is supplied to the conductor rails at 630 volts. An extensive carriage repair depôt adjoins the Stonebridge Park power station, and another carriage shed is located at Watford. The rolling stock employed on the new sections is similar to that used on the North London line, and is particularly roomy and comfortable. The trailer cars were constructed at the company's carriage works at Wolverton, and the motor cars were built by the Metropolitan Carriage, Wagon and Finance Company, Limited, Birmingham. During the busy periods of the morning and evening six-coach trains will run at 15-minute intervals from both Broad-street and Euston, while for the remainder of the day, the service will be maintained with three-coach trains run half-hourly from both termini. The new electric services will be additional to the existing service of steam trains and also to the electric service operated as an extension to the Bakerloo Tube. The excellent facilities thus provided for access to all parts of London from the suburban area lying between Willesden and Watford can hardly fail to have a very material effect upon the rate of development of that district for residential and other purposes.

FACTORY LIGHTING.

Enormous improvements have been effected in factory lighting during the past thirty years, the betterment being due in the main to the enlightened self-interest of the owners, in which indeed most improvements in industrial conditions have originated. Only after certain progressive individuals have shown the way and their example been followed by the bulk of a trade, is it practicable for the law to step in, and compel the laggards to make a move. The Home Office Committee, appointed in 1913 to inquire into factory lighting, came to the conclusion in 1915 that the time was then ripe for action of this kind, and recommended that statutory provision should be made requiring adequate and suitable lighting in every part of a factory and workshop. Under war conditions it was, however, impossible to make much progress, and, indeed, owing to the danger from air raids, it was found necessary in many cases to reduce existing standards of lighting. The standard aimed at by the committee was that in the working areas of workrooms the general illumination at floor level should not be less than ¼ candle foot, whilst in foundries the figure should not be less than 0·4 candle ft. Elsewhere than in the actual working areas it was decided that a general illumination of 0·1 candle ft. would, in general, suffice, though in dangerous parts of roadways or yards the illumination should be as much as in the working areas of workrooms. It was also recommended that with certain exceptions it should be compulsory to keep windows clean, and the enforcement of this rule would in many cases no doubt result in decided economies. In a second report issued in 1920 the committee advised that lights of high intrinsic brilliancy should be shaded when within less than 100 ft. of the workman, or else placed at such a level that the direct line of sight makes an angle of not less than 20 deg. with a horizontal plane through the workman's eye. In the case of lights within 6 ft. of the workman this angle, it was advised, should not be less than 30 deg. Other recommendations in the report dealt with reflected lights, dangerous shadows, and flickering. In a third report just issued* the committee discuss the question of how the standard of illumination demanded should vary from trade to trade, better light being naturally required for "very fine" work than for ordinary "fine" work, but so far neither their inquiries nor their experiments have led to any very definite results. Operatives engaged on very fine work seemed equally satisfied with an illumination of 100 candle ft. and with an illumination of 5 candle ft., but it was found that complaints arose if there was too great a contrast between the light on the work and the general intensity of illumination. An interesting appendix to the report shows the standards of illumination adopted in certain foreign countries and in some States of the American Union. For roadways the lowest figure adopted is 0·02 candle ft., whilst in most cases 0·5 candle ft. is considered sufficient in halls, stairways, toilet rooms, &c., as also in work which only involves the handling and sorting of rough material. Where moderate discrimination of detail is required the figures run from 1 to 2 candle ft., whilst an illumination of 5 candle ft. is considered sufficient in watchmaking, engraving, drafting and in sewing dark material. It should be added that the foregoing are minimum figures, and in American "good practice" the values stated are much exceeded.

* Third report of the Departmental Committee on Lighting in Factories and Workshops. London: H.M. Stationery Office. 1922. [Cmd. 1686.] Price 9*d*. net.

NOTES ON NEW BOOKS.

It is not usually very difficult to judge by the contents of a technical treatise for what class of reader the work has been prepared, and any doubts that may exist can generally be set at rest by referring to the preface. In the case of a work entitled "*Burning Liquid Fuel*," by Mr. W. N. Best (U.P.C. Book Company, Inc., West Thirty-ninth-street, New York), we have examined both the contents and the preface and have also considered the title, but have not been able to make up our mind as to whom the book is likely to appeal. Since it deals with statistics of liquid fuel production and analyses, atomisation, systems of storage, supply to burners, refractory materials, oil burning on locomotives and in stationary and marine boilers, as well as with the applications of oil fuel to about a score of different industries, and dismisses them all in a little more than 300 pages, it is evidently not intended for specialists, complete industries being dealt with in the scantiest manner. The furnace designer may find the numerous sectional drawings of furnaces reproduced in the book interesting and useful, but will not derive much help in his work from the subject-matter accompanying them. In general, the author is content to point to desirable characteristics with, as we think, insufficient explanation of the means by which they are to be obtained. The necessity for complete atomisation of the oil is rightly insisted on, as also is the need for using a burner which will not carbonise. There are, of course, a number of burners that are satisfactory in these respects, but only one is dealt with in the book, and we doubt whether this always "makes a flame that will fit the combustion chamber or fire-box to which it is applied as perfectly as a drawer fits an opening in a desk"—to quote another of the author's essentials. While there may be some truth in the author's statement that many people cannot learn how to burn liquid fuel, their number might perhaps be reduced if better methods than are presented in this book were adopted for instructing them. The price of the book is 5 dols.

The "*Grundlagen der Flugtechnik*," by Dr. Ing. H. G. Bader, of Berlin (Berlin and Leipzig, B. G. Teubner; price 14*s*. 6*d*.), an octavo volume of 194 pages, requires brief mention only not because of its quality, which seems praiseworthy, but because this volume on the Principles of the Technics of Flight deals only with the design and calculation of aircraft prior to 1920. After the first 142 pages, which are more or less mathematical, we come to 33 pages, in which the problem of the design of a machine is worked out, intended to carry 12 passengers with light luggage for 7 hours at a speed of 125 km. per hour, and the book closes with a very able summary of 17 pages on the general aspects of the problems. Some of the determinations of propeller efficiencies are based upon the unpublished experiments made by Dr. Schaffran with bronze propellers in the channel of the Experimental Station for Shipbuilding at Berlin.

Up till about ten years ago German engineers had in the "Hütte" a standard pocket book for the needs of both civil and mechanical engineers, in addition to the manifold handbooks dealing with special branches of the profession. Professor Max Foerster, of Dresden, in co-operation with other engineers, then decided upon compiling a pocket book devoted mainly to the interests of the civil engineer. This "*Taschenbuch für Bauingenieure*," edited by Dr. Ing. M. Foerster (Berlin: Julius Springer, two volumes; price in England 480 marks), has now appeared in its fourth edition. The third edition came out soon after the end of the war; the last edition does not differ much from its predecessor. The sections on water supply and town drainage were in charge of the late Professor Theodor Koehn; now Dr. A. Heilmann has been entrusted with the first of these sections, and Dr. E. Genzmer with the second. They are both of Dresden, as are indeed most of the contributors to this book. The general division has undergone a slight rearrangement. Volume I, of 1,112 pages, now comprises general theory, mathematics, mechanics, strength of materials, statics, concrete and ferro-concrete and other building materials, building construction, geodesy, administration and legal matters; these last subjects were omitted from the third edition, as the laws of ground rights, contract and labour were then being re-cast. The second volume deals with hydraulic engineering, earthwork and tunnel construction, the construction of roads, railways and bridges, town planning, water supply and drainage (already mentioned), and a section on engines by E. Wentzel. The 30 pages on electrotechnics are a concession to custom, though not quite on the usual lines; that section might well be omitted without being missed. Including the excellent alphabetical index, the two volumes contain 2,399 pages.

The replacement of the Bessemer converter by the open-hearth furnace affects agriculture to a degree which must not be disregarded by metallurgists. That the Thomas slag thrown away as useless in the early days, was valuable as a fertiliser, was first pointed out by the late Professor John Wrightson, in 1884, later demonstrated by the systematic experiments of Paul Wagner, at Darmstadt, and subsequently discussed in reports by Professor W. Sommerville, Sir T. D. Middleton and others. During the last decade the open-hearth process has been gaining favour, however, and the basic slag it produces is larger in bulk, but inferior in phosphate. Farmers have thus had to fall back upon other sources of phosphate. The farmers of the United Kingdom could, in 1920, obtain 500,000 tons of slag, which, with 15 per cent. of phosphate, is equivalent to much less than half of their phosphate wants. On the other hand the metallurgist, who receives more than twice as many pounds for the steel as he can expect to make in shillings out of the slag, the by-product of his steel, cannot be expected to change his steel process to suit the farmer. That mutual adaptation was desirable, and to a certain extent possible, was agreed by the metallurgists and farmers taking part in the general discussion which the Faraday Society arranged in 1920. What basic slag can do, especially on grass land, is well demonstrated in "*The Basic Slags and Rock Phosphates*," of Dr. G. W. Robertson, F.I.C., head of the chemical research division of the Ministry of Agriculture (Cambridge: The University Press; price 14*s*. net). Dr. Robertson is in touch with the steel industry, and has for years been investigating agricultural problems. Sir Edward J. Russel, F.R.S., director of the Rothamsted Experimental Station, outlines the national importance of the problems in his preface to this well-illustrated volume.

For some time it almost looked in recent years as if the adoption of a gas of high carbon monoxide percentage might necessitate the laying of separate mains for industrial and for domestic gas. That need has not arisen, fortunately. But the distribution of gas is certainly one of the important problems of the gas industry. When Mr. Walter Hole brought out the first edition of "Distribution of Gas," in 1907, he had no rival in his successful attempt to deal in one volume with the manifold problems of the flow of gases in mains and pipes, the proportioning of the pipes, the most suitable gas pressures, the laying, jointing and preservation of the mains and their materials, gas fittings, gas fires, &c., and his work met with general appreciation. The further enlarged editions have sustained the reputation of the work. Mr. Hole is superintendent of the gas mains and distribution department of the City of Leeds, and was till 1920 examiner on gas supply to the City and Guilds Institute of London. It is not astonishing that the fourth, re-written edition of his "*Distribution of Gas*" (London: Benn Brothers, Limited; 8, Bouverie-street, E.C. 4; price 50*s*. net, bound) should have run into 699 pages small quarto. At the same time we do not see what the chapter on Gas Engines, their sparking devices and silencers has to do with the subject, and why illustrations of the Laval steam turbines are incorporated in the chapter on Compressors. The chapters on Industrial Uses of Gas and on Inferential Meters are new, while the section of the previous editions on domestic uses of gas has been cut out. Explosion risks and leakage dangers possibly went with those excisions. While the additions are welcome we think that more attention might have been paid to the corrosion of gas meters; the 1918 report on the Life of Gas Meters was not the last word on that subject.

BRITISH PRODUCTION OF IRON AND STEEL.—Production of pig iron in June amounted to 369,200 tons, a decline of 38,700 compared with May. The number of furnaces in blast at the end of the month numbered 115 compared with 110 at the end of May. The production included 109,700 tons of hematite, 139,200 tons basic, 78,900 foundry and 18,400 tons forge pig iron. The production of steel ingots and castings also declined in June to 400,200 tons compared with 462,300 tons in May.

LORRY CONVERSION ATTACHMENT; ROYAL AGRICULTURAL SHOW, CAMBRIDGE.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.

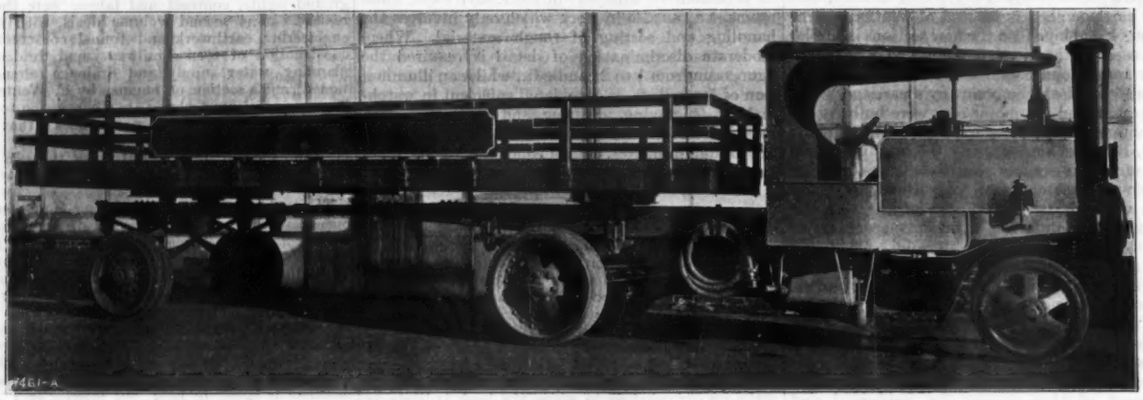


FIG. 1.

IN our description of the exhibits at the Royal Agricultural show at Cambridge, which will be found on page 38, we gave a brief account of a six-wheeled steam lorry shown by Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich. This vehicle, which we illustrate in Figs. 1 to 4 annexed consists of an ordinary steam lorry fitted with a trailing attachment, the connection between the two being so arranged that not only can the complete vehicle accommodate itself without strain to any inequalities of the road surface, but when turning a corner the trailing wheels follow always exactly in the track of the driving wheels. The fore end of the body rests on a turntable on the chassis of the steam wagon and the rear end rests on another turntable on the trailing attachment. The latter turntable is able to slide in a fore and aft direction, this, of course, being necessary in order to maintain constant its distance from the front one, whatever may be the angle of the steam wagon to the pole of the trailer. The steam wagon, with its trailer attachment carried a body 24 ft. long, or just double the length of the standard body which would be fitted to the steam wagon alone, so that an enormously increased transportation capacity is obtained at very slight cost.

On Wednesday last we were able to be present at a demonstration of the performance of the vehicle at Ipswich under various difficult conditions, and its behaviour left nothing to be desired. The first tests were made with the wagon unladen, and as a preliminary the weight on each pair of axles was taken on a weighbridge. In this condition the figures were as follows: front axle, 3 tons 8 cwt. 2 qrs.; driving axle, 3 tons 12 cwt. 1 qr.; trailing axle, 2 tons 8 cwt. 3 qrs. It may be mentioned that the engine was carrying 150 gallons of water and 4 cwt. of coal. After the weighing, the vehicle was put through backing-tests, and the driver appeared to have no difficulty in manœuvring it in awkward situations. It appeared quite impossible to overturn the wagon when backing, because when going backwards, if the steering wheels were locked full over, the driving wheels skidded and the wagon refused to move. This was demonstrated several times with the same result, although the adhesion conditions were excellent. The wagon could be run round and round backwards or forwards in a circle of 38 ft. external diameter, so that it could turn in a 38 ft. road, which is not bad considering that its overall length is 32 ft., or 1 ft. less than the maximum legal length for such a vehicle.

After these tests the wagon was driven to a local brewery and loaded with 43 barrels of beer. Its axle-weights were then taken, and proved to be: front, 3 tons 17 cwt. 2 qrs.; driving, 7 tons 12 cwt. 1 qr.; and trailing, 6 tons 15 cwt. 3 qrs. Comparing these with the unladen weights it will be seen that the vehicle was carrying a paying load of 8 tons 16 cwt. The next test was possibly the most severe of all, at any rate it was the most striking. The wagon was taken through narrow streets with sharp turnings and finally down a steep hill with a gradient of 1 in 10. The road on the hill was measured and found to be 22 ft. wide between the kerbstones. On the hillside was a gateway 11 ft. 11 in. between the posts, and the wagon came down the hill and turned in at the gateway with no trouble at all. It was then backed out so as to mount the hill again, and although this manœuvre was not executed quite so well, there was really no cause for complaint, and the wagon got out backwards all right and was off up the hill again with its load in a few minutes. Next it was taken over steep bridges and over bad roads to demonstrate the flexibility of the body, and finally braking tests were carried out on a hill with a gradient of 1 in 11. In these tests the wagon was repeatedly pulled up in a yard or two by one or other of the brakes. These brakes are quite independent, one acting on the driving wheels, and the other, operated by a steel cable, acting on the trailing wheels. As we have indicated, the wagon went through all its tests with great credit, and considering its size and capacity it was surprisingly handy. Messrs. Ransomes, Sims and Jefferies, Limited, manufacture the attachment in various sizes to suit both petrol and steam lorries, so that existing four-wheeled vehicles can be converted into six-wheelers of the type described and their carrying capacity practically doubled without great expense.

Fig. 2.

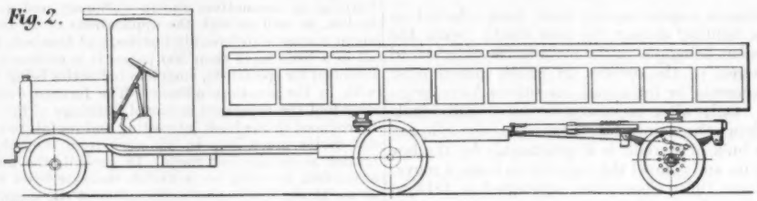
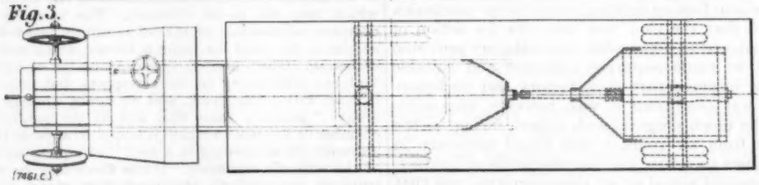


Fig. 3.



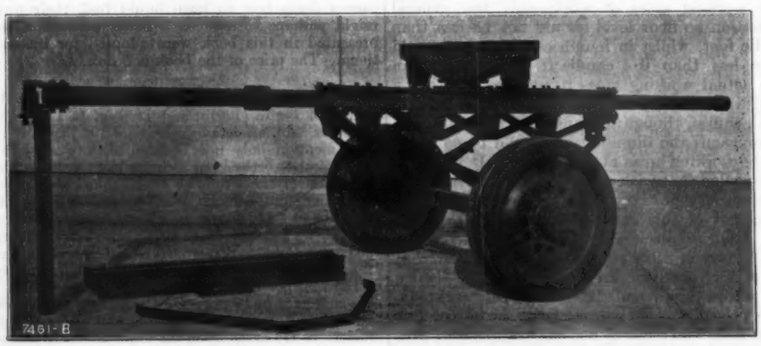


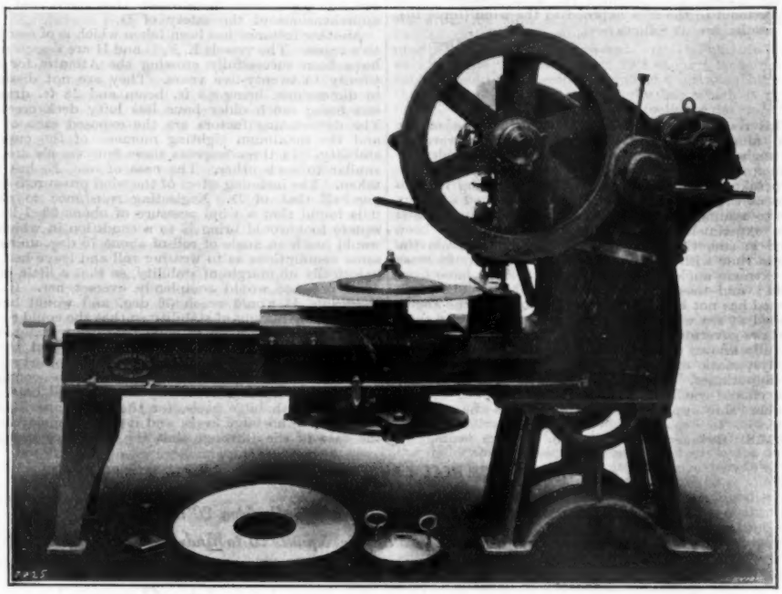
FIG. 4.

THE INSTITUTION OF NAVAL ARCHITECTS: ERRATUM.—In our account of the meeting of Tuesday, the 4th inst., the remarks by Mr. Doyére, in the middle column of page 20 *ante* had reference to former torpedo-boat carrying ships, and not to torpedo-carrying ships, as printed by inadvertence.

WOODWORKING MACHINERY REGULATIONS.—We have received from the Home Office a copy of draft regulations which it is proposed to issue in connection with woodworking machinery. Early in the year the Home Office issued a proposed set of regulations to which, however, objection was taken by various employers' federations. As a result of a conference in March, agreement was arrived at with these bodies, and the present draft has been revised in the light of the discussions which have taken place. The regulation contains a section devoted to definitions, and the main portion is divided into two parts—(1) duties of employers, and (2) duties of employees. The first of these parts is concerned with the fencing and arrangement of machines, and states detailed requirements in regard to circular saw benches, band saws, planing machines, &c.

SAW NOTCHING MACHINE WITH AUTOMATIC FEED.

CONSTRUCTED BY MESSRS. HORDERN AND MASON, ENGINEERS, BIRMINGHAM.



A MACHINE which was originally designed for use in connection with hot saws, but which should have a considerably wider application and should be of great value in many workshops, is illustrated above. It is intended for notching the teeth of circular saws. The teeth are notched to size and left sharp so that subsequent grinding for hot-sawing or similar work is unnecessary. Either plain discs can be notched or old saws may be re-cut without it being necessary to crop off the old teeth, which are simply notched a little deeper. The machine has a horizontal bed carrying a saddle on which the saw to be notched is carried. The saddle is traversed along the bed by means of a screw operated by a hand wheel which can be seen at the left end of the machine in the figure, and it will be clear that this traversing of the saddle allows saws of different diameters being dealt with. The capacity of the machine ranges from saws 18 in. in diameter to saws 6 ft. 6 in. in diameter.

The notching mechanism, as will be gathered from the figure, is on the lines of an ordinary power press and need not be referred to in detail. The special feature of the machine lies in the automatic feeding mechanism by which the saw being operated on is stepped round, by the space of one tooth, after each notching operation. As will be seen from the figure, a large diameter ratchet wheel lying in a horizontal plane and connected to the vertical saw spindle, is arranged on the underside of the carriage. Over this wheel an oscillating arm works which carries a pawl at its outer end. A second pawl, to be seen in the figure, serves to lock the ratchet wheel in each position reached. The oscillating arm is operated by a sliding bar which is situated on the opposite side of the machine from that shown in the illustration. This sliding bar is moved to and fro' by means of a bell crank lever, which is oscillated by a connecting rod working from a disc on the end of the main shaft of the press. The crank pin of the disc is held in a slot and may be moved in or out to adjust the stroke of the connecting rod and so of the oscillating arm which operates the ratchet wheel. This arrangement allows the amount of feed of the saw to be adjusted to one, two or more teeth of the ratchet for each stroke of the press. As will be clear this gear can operate in any position of the saddle, so that saws of any diameter within the range can be dealt with. The saddle is clamped in its working position by means of a thumb screw. A knock-out arrangement stops the machining when the full circumference of the saw being dealt with has been completed. The machine is manufactured by Messrs. Hordern and Mason, of Vulcan Works, Vesey-street, Birmingham.

STATUTORY REGISTRATION OF ARCHITECTS.—The Council of the Royal Institute of British Architects have appointed a Committee for the purpose of drafting a Bill for the Statutory Registration of Architects.

STABILITY OF LARGE SHIPS.*

By Sir JOHN H. BILES, K.C.I.E., LL.D., D.Sc. (Hon. Vice-President).

SHIPS of very large size of many nations are not uncommon, and the question of their stability is one of great interest to the passenger and the naval architect. It is with a view to promoting a discussion on this subject that the following remarks are made:—

STABILITY OF A SHIP ON ENTERING OR LEAVING PORT.

Before the contracts for some new ships were placed, my advice was asked as to the amount of G.M. (metacentric height) which should be provided for in the light condition. I suggested 1 ft. as a proper amount—not that a less amount would not have been satisfactory, but that experience had shown that during the process of building, additions were likely to be made which would tend to reduce the amount in that condition. Many ships have G.M. in the light condition zero or negative, and are satisfactorily worked. Obviously, the reliable method of determining the sufficiency of the stability of a ship is to compare the amount which she may have in any condition in which she is likely to be, with that which satisfactory ships doing the same kind of work actually have. The recognised method of comparison is to find the G.M. in two conditions—first, the load condition, *i.e.*, with coal, stores, passengers, baggage, mails, fresh water and cargo all on board. This corresponds to the state the ship will be in at the beginning of a voyage. The second is the arrival condition, in which coal, stores and fresh water have been nearly all consumed, and such water ballast added as may be found by experience sufficient to enable the ship to be satisfactorily worked. There is no doubt about the weights of any of the things carried in the ship, except the cargo, which is of such varied character and quality that it is difficult to predict what its weight will be before it comes alongside the ship, and is not easy to determine even when it is there. The recognised method of allowing for cargo weights is to assume that they will be sufficient to load the vessel to her load water-line, and that the centre of gravity of the weight will be at the centre of gravity of the volume of the compartments of the ship which are devoted to cargo. Upon this assumption the G.M. in both leaving and arriving conditions, can be determined. The assumption is believed generally to be on the safe side, because it is the general practice, where cargoes are varied in character, to put those of the heavier kind below. It is also frequently found in practice that general cargoes do not fill the cargo spaces, as the parts vary in size so much that it is quite impracticable to fill the spaces up to the beams. The consequence is that the centres of gravity of the cargo in the different compartments are all below the centres of the spaces, and the centre of gravity of the ship and cargo is lower than the calculation shows.

Judged by this method, it may be found that a projected ship has as much or more G.M. in the load condition as many other large steamers. In the arriving condition, there may be special conditions in the ports of arrival that make comparison with steamers other than those trading to that port of little value. In some cases the margin of draught is so little that a small inclination of the ship will cause an increase of draught sufficient to cause her to touch the ground at the bilge. To determine the minimum amount of stability, it is necessary to know to what angles similar ships heel in entering the port; what their arriving draughts are; what amount of increase of draught is associated with definite angles of heel. Such information is not always available, but it is desirable that it should be obtained, and the results interpreted.

It is, however, of interest to compare the two conditions of the ship which she will have to be in when leaving and arriving in port. They are (1) the fully laden condition when leaving, and (2) the arriving condition after having crossed the ocean. The most unfavourable condition on leaving port, so far as liability to touch the bottom is concerned, is that when the ship is fully laden and is loaded with a cargo which will, in addition to filling the ordinary hold spaces, also fill the portable passenger spaces which may be used for cargo and the reserve bunker with cargo if this is so used. A special case has been taken by way of illustration. In this condition, which we may call (1), the vessel will leave with a G.M. of, say, 2·2 ft. If the ship does not incline, the draught at which she leaves the wharf will be the maximum draught which we need consider, and it may further be noted that in the case chosen a heel of 2 deg. on either side will not increase the draught, but for every additional 1 deg. of heel, the draught will be increased by about 6 in. In the case of the ship arriving at the port, there are two conditions, (2), when the ship arrives with a cargo of about 2,000 tons weight, and with about 1,000 tons of coal in the bunkers. In this condition, the ship will have a draught of 26 ft. 3 in., and a G.M. of 1·8 ft. The other unfavourable condition, (3), is when she arrives with a small quantity of cargo, say, about 700 tons, in which case she will have a draught of 24 ft. 10 in. and a G.M. of 1·3 ft. Whatever the disturbing cause may be which heels the ship, we can compare the relative effects in these three cases, (1), (2) and (3), and though the information may not be available to say to what angle the ship will heel, it can be seen what are the relative effects upon the increase of draught, due to any assumed disturbing cause.

The following table shows the degrees of inclination and actual draughts for the three conditions, (1), (2) and (3), due to a series of disturbing causes, which in succession will heel the ship in condition (1) to the number of degrees named in the column headed (1). The number of degrees in the columns headed (2) and (3) are the corresponding inclinations that the ships will have for the same disturbing cause.

		(1)	(2)	(3)
Degrees of inclination	...	5·0	6·0	8·4
Draught in feet ...	...	30·0	28·3	28·1
Degrees of inclination	...	10·0	12·0	16·8
Draught in feet ...	...	32·7	31·5	32·5
Degrees of inclination	...	13·0	15·6	20·0
Draught in feet ...	...	34·2	33·3	34·2

From this table it will be seen that in all cases the draught of the ship arriving is not more than that of the ship leaving.

Even in the case where the ship is inclined to the greatest angle, that of the ship leaving port is not less than the others.

It seems unlikely that there can be disturbing causes which could give the ship so much heel, because, if there were, other ships would have been heeled to similar angles, and their draughts would have been increased by about the same amount. If they had been, these vessels would have touched the bottom, and the case of the chosen vessel would be no worse than has been the case with them. If they have not touched, then the disturbing cause sufficient to make them touch cannot exist, but in none of the cases does it appear that any advantage would be gained in endeavouring to increase the stability of the ship by adding ballast to the ship or in any other way to avoid touching the bottom. The draught would be increased by the amount of the ballast, and in practically all cases the ship in the arriving condition is safer from touching than the ship in the leaving condition. It does not, therefore, seem to be desirable in the instance chosen to add ballast to the ship on account of the port conditions. Each case may have to be investigated on its merits, but a similar method of investigation should be followed.

The only other question which need be considered in the matter of the stability is that of the heeling of the ship, due to the action of the rudder, when she is in smooth water, and the effect that this heeling will have upon the minds of the passengers. No heeling is likely to be produced which can be dangerous to the ship. But a tender ship arriving in port is very likely to have heeling and oscillations set up under rudder action. There is no doubt that some passengers do not understand why a ship should incline and oscillate in smooth water, but oscillation by itself has no terrors for them, because when at sea in comparatively smooth water and with some small swell on, the vessel will roll for days to degrees of inclination of about an average of 5 deg., with a maximum of 10 deg., and the passengers take no notice of it. It seems, therefore, difficult to believe that anyone will be deterred from crossing in a ship on account of the tendency to toll in smooth water, under the rudder action, but the reputation of a ship for stability has to be carefully guarded, and it may be worth while to err on the side of large rather than small G.M. to avoid throwing doubt on a vessel's stability.

If the chosen vessel is in no respect different from other ships of the same class, and there has never been any question as to the safety of such ships at sea, with a G.M. as small as the chosen vessel is likely to have, no water ballast need be added to prevent the vessel from touching when rolling during entering port. It seems, therefore, desirable, before adding water ballast,

* Paper read at the Paris summer meeting of the Institution of Naval Architects, July 6, 1922.

to consider very carefully the above facts and arguments, and to gain further experience with the ship, before attempting to reduce her draught in the inclined condition by adding water ballast when entering port.

STABILITY OF A SHIP AT SEA.

The stability of a ship at sea may be considered from two points of view, first, safety; second, comfort of passengers.

Safety.—By this is meant freedom from liability to capsize. The tendency to return to the upright is the measure of the stability. The causes which move the ship from the upright are (*a*) the action of the sea, (*b*) the action of the wind, (*c*) the shifting of weights inside the ship so that the centre of gravity of the whole ship and her loading are not on the middle line, and (*d*) the action of the rudder, about which it is not proposed to say more.

(*a*) *The Action of the Sea.*—This produces rolling when the sea is not directly ahead. The worst case of rolling is when the period of the waves and the natural period of the rolling of the ship are nearly the same. The natural period of rolling of a ship is what she would have if inclined to some appreciable angle in still water and released from it and allowed to oscillate. The period of the largest Atlantic ocean waves, those of 500 ft. to 600 ft. long, is 10 seconds to 11 seconds. The period of a complete oscillation of a large Atlantic liner is about 20 seconds. The period of a ship varies as the beam and inversely as the metacentric height, so that the broader the ship and the smaller the metacentric height the longer will be the period of roll of the ship and the less will the waves tend to synchronise with and therefore increase the rolling of the ship. Hence, small metacentric height is conducive to small rolling, and so far as the action of the sea alone is concerned, is conducive to safety.

(*b*) *The Action of the Wind.*—The wind produces the greatest heeling effect when blowing broadside on, and if it has continued for long in that direction will have raised a corresponding sea which will tend to roll the vessel. The wind tends to produce a mean inclination of the ship, and she will tend to oscillate about this mean inclined position. Suppose, for instance, the ship has a mean steady list of 10 deg. due to the wind, and that the action of the sea alone would cause her to roll 10 deg. on each side of a vertical line, she will roll when under the action of the wind to approximately 20 deg. to leeward of her own upright position. As only large waves can make a large ship with a small G.M. roll to large angles by synchronisation, it is evident that generally it is better to have a ship with a small metacentric height which will therefore roll little, though that little may be about an inclined axis, than one with a large metacentric height which will roll to great angles about a less inclined axis.

The real question is what smallness of metacentric height is permissible; in other words, to what angle a ship may be allowed to heel under a steady wind pressure in order that her rolling may be reduced, so that the maximum angle to which she inclines shall be the least. Take an example of a ship with, say, 2½ ft. of metacentric height which under a wind pressure of, say, 8 lb. per square foot in a heavy gale, force 9 to 10, would incline to a steady angle of 5½ deg. Such a ship would have a period of oscillation of, say, 20 seconds. If this ship's metacentric height be decreased to 1¼ ft. she would have a steady heel about 11 deg. and her period would be increased to 28 seconds.

If the 20-second period would cause her to roll at least 5½ deg. (the difference between 5½ deg. and 11 deg.) more than the 28-second period ship, her maximum angle of roll to leeward would be more than that of the less stable ship. The motion of the 28-second period ship would be much slower than that of the 20-second period ship. The disadvantage of a greater mean inclination would exist in the less stable ship. Generally, there would be less liability to rolling in the more tender ship, so that the disadvantage of the greater mean inclination might be more than balanced by the advantage of the reduced frequency of rolling and the reduced maximum angle of rolling. It is therefore evident that for a steady wind the reduced stability may, on the whole, in this case, be an advantage. When we consider winds of exceptional force such as forces of 11 and 12, the mean angle of inclination may be undesirable, and it may be desirable to alter course sufficiently to reduce the heeling effect of the wind in the tenderer ship, but this is a very exceptional condition which can be met with safety.

The effects of gusts of wind of great force acting upon a ship when rolling have received some consideration. It has been assumed that it is possible, under very exceptional circumstances, for a ship to roll through 20 deg. on each side of the upright, and that when rolling to windward through 20 deg. she may at the end of a windward roll be struck by a squall of extreme violence which would, by its continued force and by the action of the roll from windward, cause her to roll to a much larger angle to leeward. To estimate the effect of such a combination of circumstances is not easy. The effect of resistance to rolling through large angles is not easy to estimate, but it is known to be very considerable, and if the roll to leeward due to the squall should be 30 deg. to 40 deg., the total roll would be 50 deg. to 60 deg., including the 20 deg. from windward. This roll would take place in less than 10 seconds and the velocity of oscillation would be very high. The effect of the wind pressure acting on the surface of a ship is not easy to determine. It can be calculated on an assumption as to the wind pressure on the surface in terms of its area and angle of inclination, but these assumptions may not be accurate. The only thing that seems to be possible is to compare the rolling of ships under such assumed circumstances, and to compare ships, on such assumptions, which have for years successfully withstood the storms of the ocean with any untried ship whose safety it is desirable to estimate.

This has been done in the case of four ships, of which A, B and C have been on service, and D, which is untried. Taking them all in the same conditions as to lading, with a light cargo and in a spent and ballasted condition at the end of a voyage, it is possible to make a comparative estimate disregarding resistance to rolling, which is very large but proportionately the same in all the vessels, and assuming the wind pressure to be proportional to the area exposed to the wind (force 10), the results are as follows:—

	Deg.
A	32·5
B	39·5
C	33·5
D	37·5

This result is reached by equating the area of the wind moment curves from 20 deg. to windward to the angle on the curve of stability which includes the same area.

To take account of the resistance to rolling in such ships as these is not very easy. The method of doing so is to assume coefficients of resistance which are based upon experiments made upon ships which have been rolled in smooth water by moving weights across the ship in time with the rolling so as to gradually increase the extreme angle reached. Very few ships have been rolled; and these are nearly all warships. The angle reached has not been very great, nothing like the angles reached at sea when rolling under the action of waves. The laws governing the action of bilge keels in rolling are not fully known on account of the difficulty of carrying out systematic experiments on a large scale to verify any hypotheses. The best that can be done at present is to choose coefficients of resistance from the nearest suitable ship upon which experiments have been made.

H.M.S. Revenge was rolled in smooth water by swinging her turrets and running 300 to 400 men across the ship synchronously with the ship. She was rolled without headway and also at speeds of 10 knots and 12 knots. The bilge keels were 200 ft. long and 3 ft. deep, tapering at the ends, the actual area for both bilge keels being 1,170 sq. ft. The centre of the keels was 41 ft. from the centre of gravity of the ship. The dimensions of the ship were: Length, 380 ft.; breadth, 75 ft.; draught, 27 ft. 6 in.; displacement, 14,300 tons. The period of a single swing was about 8 seconds, that is, 16 seconds for a double swing. The metacentric height was about 3¾ ft.

The results of the experiments on the Revenge may be used for approximating to the resistance to rolling of ships like A, B, C and D, which are ships of about the same order of beam and draught. It will also be possible to compare ships such as these with other vessels of large dimensions which have been running in all kinds of Atlantic weather for many years.

If the resistance to rolling be neglected a comparison between ships having similar elements of resistance such as bilge keels can be made which, while not giving the actual angles to which the ships will roll, will give a means of comparing new ships with those that have successfully withstood the storms of many years. But we may approximate by using the experiments on the Revenge to the effect of resistance and see whether the comparative results are much affected by this resistance. When this is done it must not be assumed that the reduced angles of roll so determined are accurate. They will, as before, only give a comparison of new vessels with old and successfully tried ones. The assumptions which have to be made in order to obtain quantitative results of considerable magnitude (and it is of little use to consider only cases in which the rolling angles are small) must necessarily be only assumptions, and may not represent the actual facts of the case. But they will afford a comparison which for somewhat similar ships ought to enable us to form an opinion on the safety of new ships. On the same assumptions as those already made when resistance to rolling was neglected, viz., being struck by a squall, force 10, when at 20 deg. to windward, the resistance has been approximately calculated with assumed pressures of wind, the angle reached being as follows:—

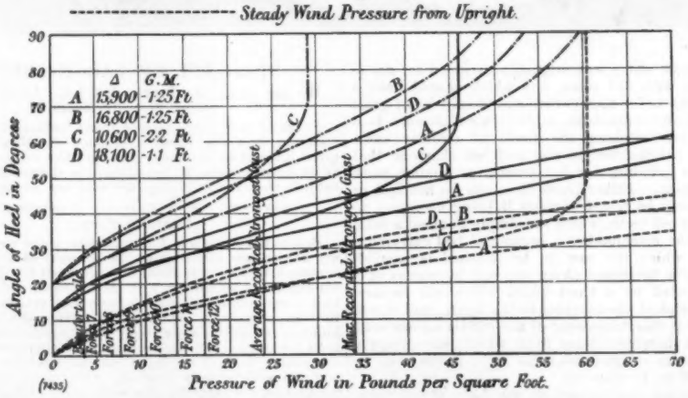
	Deg.
A	25
C	24½
D	27½

B is so near to D that the results have not been worked out. It seems from these results that there need be no apprehensions of the safety of D.

Another instance has been taken which is of comparative value. The vessels E, F, G and H are vessels which have been successfully crossing the Atlantic for from twenty to twenty-five years. They are not dissimilar in dimensions, being 63 ft. beam and 28 ft. draught, but being much older have less lofty deck erections. The determining factors are the exposed area of side and the maximum righting moment of the curve of stability. In these respects these four vessels are very similar to each other. The case of one, E, has been taken. The inclining effect of the wind pressure is about one-half that of D. Neglecting resistance to rolling it is found that a wind pressure of about 32·7 lb. per square foot would bring E to a condition in which she would reach an angle of roll of about 70 deg. under the same assumptions as to weather roll and leave her with practically no margin of stability, so that a little higher wind pressure would completely overset her. In this condition, D would reach 58 deg. and would have a considerable margin of stability so that she could receive a considerable increase of wind pressure without oversetting. It may therefore be safely assumed that D is at least as safe as E which has for over thirty years successfully continued to run. If we take account of resistance to rolling, the comparison is still better for the ships with bilge keels, for the four ships E, F, G and H have no bilge keels, and it was demonstrated in the case of the Revenge that the resistance to rolling due to bilge keels is such that at comparatively small angles the angle of roll without bilge keels was about three times what it was with bilge keels. In the case of D, if resistance be taken into account, a 32·7 lb. wind pressure will incline her in a squall to 43½ deg., while E would probably incline to 60 deg. It seems, therefore, that there need be no fear for the safety of D.

ANGLES OF HEEL CAUSED BY SQUALLS AND BY STEADY WINDS.

Unresisted Rolling in Squalls from 20° to Windward.
Resisted Rolling in Squalls 20° to Windward.
Steady Wind Pressure from Upright.



(*c*) The third cause which has to be considered is that of shifting the centre of gravity of the ship by shifting weights inside her. If the vessel rolls to large angles there will be a tendency to shift fuel and cargo. There can be little chance of shifting coal, because in the condition of loading assumed there is but a small quantity of coal left, and this generally will be in the side bunkers which will not permit of much shifting. In other conditions of loading, such as the reserve bunker being partially filled, there is not much chance of coal shifting, as the fireman's passage or some other longitudinal division is in the ship, but the centre of gravity of the ship will be lower and the stability greater. Loose water or oil may cause shifting of the centre of gravity of the ship, but tanks are usually well divided, and it is usual to empty a tank before beginning to broach another. This should be done as a matter of routine. Where practicable the lee tank should be emptied before the corresponding weather one. The free surface of a tank partially filled tends to set up oscillations which tend to neutralise the effect of inclination. The shifting of cargo is possible, but with ordinary precautions in loading this is not likely to occur. In the case of grain cargoes the trunks leading to the holds will necessarily be well filled to provide feeders for the sinking of the grain. The hatches of the decks below on the trunks should be left off to allow the grain to flow through them as it settles. Special instructions for stowing the grain to avoid the chance of shifting should be systematically given effect to. With these precautions there should be no chance of any appreciable shift of coal or cargo in these vessels.

In the case of heavy rolling due to unusually great wind pressures, it will naturally suggest itself to the master of the vessel to alter course so as to avoid the effects of the abnormal wind pressures. These cases

will occur too seldom to interfere appreciably with the successful running of the ship.

The comfort of passengers in rolling is dependent largely on the maximum angle of roll and the period in which this angle is rolled. Those who have been to sea in quick rolling ships, especially if the ships are rolling through large angles, are familiar with the great acceleration which their bodies experience, especially on the top decks far distant from the centre of motion. In clear transverse spaces in broad ships the effect of this acceleration is to cause them to find difficulty in holding on to some fixed part of the ship, and if they do not happen to have something to hold on to they will find the operation of being stopped fraught with risk of knocks and possibly bruises. Hence, it is desirable to provide long periods and small angles of roll for the comfort of the passengers.

The question of the relation between the effect of the wind pressure on modern high-sided ships and the metacentric height is one deserving of the most careful consideration. The curves shown in the figure opposite give the angles of heel of the ships A, B, C, D, under wind pressures acting steadily or in squalls. The angles of heel are given in the cases when resistance is and is not taken into account.

I am indebted to the Fairfield Shipbuilding and Engineering Company of Govan for the assistance which their staff, under the direction of Professor Hillhouse, gave me in making the calculations referred to above. The method of calculation, together with some illustrations, is referred to in an Appendix, but as this kind of calculation is not suited to a summer meeting it has been temporarily omitted.

No attempt has been made to determine the angles of roll due to the action of the sea. This subject is best treated experimentally. To those interested a summary of the general question of rolling given in my Presidential Address to the Engineering Section of the British Association in 1911 (see Transactions of Section C, British Association meeting at Portsmouth, 1911) may be usefully consulted.

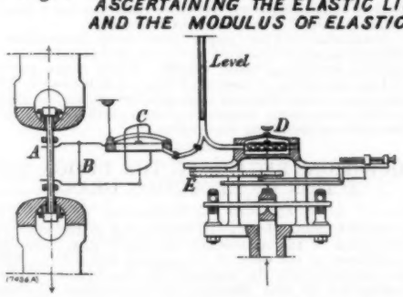
TESTING MATERIALS FOR SHIPBUILDING.

*Some Points of Interest in Connection with the Testing of Materials for Shipbuilding.**

By M. LEON GUILLET, Professor of Metallurgy at the Conservatoire National des Arts et Métiers and at the École Centrale des Arts and Manufactures, Vice-President of the Société des Ingénieurs Civils de France.

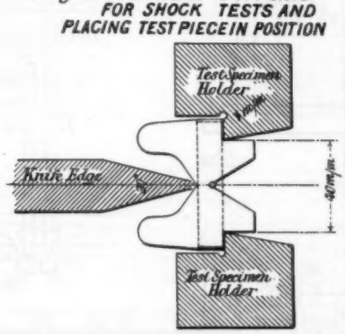
Introductory.—The object of this paper is to draw the attention to a few points which are comparatively new regarding the methods of testing materials, more particularly materials employed in shipbuilding. This will be done very briefly, and some reference will be made to earlier papers on the subject.

Fig. 1. GUILLERY APPARATUS FOR ASCERTAINING THE ELASTIC LIMIT AND THE MODULUS OF ELASTICITY



A. Test Piece. B. Double Articulated Parallelogram.
C. Water Chamber. D. Second Chamber.
E. Regulating Mechanism for Second Chamber.

Fig. 2. CONTROL OF SUPPORTS FOR SHOCK TESTS AND PLACING TEST PIECE IN POSITION



1. *Tensile Test.*—This test always forms the basis of specifications. While it is easy to measure the breaking strength, the elongation and the structure, it is sometimes very difficult to obtain the elastic limit with any degree of accuracy. Many methods of obviating this difficulty have been evolved, but in practice not one is entirely satisfactory, and the Commission Permanente de Standardisation (French Standards Committee), which has its offices at the Ministère du Commerce et de l'Industrie français, has had to be satisfied with the following method of verification: The test-piece is subjected to the load specified as the elastic limit, and on releasing the load after a certain time no permanent set must have taken place.

The determination of the modulus of elasticity is a very delicate operation, and has to be carried out in a research laboratory. It is found from the results of all the tests which have been made that the modulus for steels is constant whatever treatment is applied, its value lying between 18,000 and 20,000. This coefficient is not very often determined in practice. To-day when there is a very great variety of materials and a certain risk is often incurred in using them, this state of things cannot continue, and it would certainly be an advantage if the determination of the modulus were made less difficult. M. Guillery, who has already done much to simplify methods of testing, has just invented (see *Revue de Métallurgie*, February, 1922, "Mémoires," page 101) an extremely ingenious device which enables the modulus of elasticity to be obtained without difficulty (Fig. 1).

"This method consists of a cylinder and piston, the rod of which is attached to one of the jaws. The pressure is produced either by hand or by means of a belt, by two special high efficiency pumps, one for quick action and the other for slow action with high pressure. A reversing distributor enables the principal piston of the machine to be raised or lowered. On the bar are fixed, at a definite distance apart, two stops which can be rapidly fixed and removed, and the distance between them determines that part of the bar which is to be tested. The knife-edges of two branches of the amplifier, a double-jointed parallelogram suspended to the frame of the machine, rest on these stops. One of the two horizontal branches of this jointed parallelogram carries a water chamber, one of the walls of which is formed by a metal plate with a rubber covering; in this way the chamber is made watertight, and at the same time a certain degree of movement is possible, with a consequent variation of volume in the chamber. It is evident that the parallel movement of the stops causes no variation of volume in the chamber, but the difference in the distance between the stops causes a displacement magnified three times at the opposite side of the jointed parallelogram.

"The chamber is under pressure, and is connected by a rubber tube to a glass tube, the section of which, as compared to the surface of the movable wall, is such that the level of water in the glass tube drops 2,000 times more rapidly than the elongations which are produced. Thus the elongations are shown on a greatly magnified scale by the fall of the water level in the glass tube. The pressures shown by the gauge are exerted on a frictionless piston which rests on a calibrated spring, the deflections of which are proportional to the loads. These deflections are transmitted to the movable wall of a second water chamber of the same type as the first, by a system of levers separated by a roller, the displacements of which allow of the movement transmitted being reduced or increased, and at the same time kept proportional to the deflections. But the arrangement is such that the loads when increased cause the level of the water to rise in the tube. Thus the loads are represented on a scale chosen by the operator by a rise of water in the glass tube. The second water chamber has another movable wall regulated by hand so as to control the movement of the level of the water in the tube from a fixed reference point.

"It is therefore seen that, since by the displacement of the roller it is possible to cause a variation in the action of the loads, it is easy to find a position of the roller which will cause the loads to effect a rise in the level of the water equal to the distance it falls as a result of the elongations. Thus if the modulus of elasticity is constant, a constant level during the period of elastic deformation is obtained, that is to say, the graphical representation of the test of the scale of the two movements in the tube will be, for this period, a straight line inclined at an angle of 45 deg. to the axes of the co-ordinates. The level will remain constant until the end of the proportional elongations, and its fall will be very easily observed, as the elongation is so greatly magnified. It is easy to see that the variable scale of the loads is an indication of the modulus of elasticity."

It is therefore sufficient to graduate one of the levers which transmit the stress; a pointer fixed to the roller gives the value of the modulus of elasticity. The graduation is from 7,000 to 30,000.

2. *Falling Weight Test.*—Falling weight tests on notched bars have become very common as a result of the war. In France the Charpy and the Guillery testing machines are very generally employed. It is known that very important publications have been issued setting out the conditions to be fulfilled in order that the results may be comparable. The Commission Permanente de Standardisation has specified the following method of procedure:—

"It is not necessary that the type of testing apparatus should be fixed, provided that the principle of measurement and the accuracy of the graduations have been verified beforehand. The following conditions, however, should be fulfilled by the test: The bar shall rest on bearers, 40 mm. apart, and shall be very accurately placed before the blow is applied. The bearers shall have their upper surfaces rounded to a radius of 1 mm. A clearance in accordance with that shown in Fig. 2 shall be allowed in order to reduce friction at the extremities and to avoid the wedging of the bar.

"The knife-edge fixed to the falling weight shall have a triangular section, the angle at the apex not being greater than 30 deg. The striking edge shall be rounded to a radius of 1 mm. It is absolutely necessary that the distance between the bearers shall be very frequently verified with a special template, and it is also necessary to ensure that the knife-edge fixed to the falling weight is exactly in the middle of this distance. The position of the bar on the bearers must also be very carefully verified for each test with a special template, the position of the notch being taken into account. The speed of the blow shall not be less than 5 m. per second. Unless any figure is specially prescribed for the temperature, it shall lie between 15 deg. and 20 deg. C. The influence of the temperature is much more marked than in any other method of testing."

The Commission Permanente de Standardisation has also drawn attention to a new test-piece which combines the two types employed in France, that of M. Mesnager (55 mm. by 10 mm. by 10 mm., the notch 2 mm. by 2 mm. rounded at the bottom), and that of M. Charpy (55 mm. by 10 mm. by 10 mm.), the notch being formed by a cylindrical hole 1·3 mm. in diameter, tangential to the axis, opened out by a saw cut 1 mm. wide. The former test piece breaks with difficulty in the case of resilient metals; the second often gives figures which are comprised within a very limited range. The dimensions of the new piece are 55 mm. by 10 mm. by 10 mm.; the notch has a cylindrical base having a radius of 1 mm. and a depth of 5 mm. It has been the subject of study in different quarters, but it has not yet come into general use, and it is too early to say if it will have the utility expected of it.

3. *Ball Hardness Test.*—The ball hardness test is the only hardness test in current use; the sclerometer has not yet emerged from the region of research, and the scleroscope has practically fallen into disuse in France. The employment of the ball hardness test has increased to an even greater degree than that of the falling weight test as a result of the exigencies of the war. All works where heat treatment is applied employ the test, and it is also used to obtain the breaking strength of annealed material (the formula does not apply for hard drawn or hardened materials). It is known that:—

$$R = C\,\Delta$$

R being the breaking strength; Δ the Brinell figure ($\Delta = \frac{P}{a}$ where P = the pressure applied, and a the area of the spherical cup in mm.²); C is a constant for the same class of metals.

$C = 0{\cdot}356$ for steel.
$C = 0{\cdot}50$ for brass.

For ordinary cast-iron the formula is a little less simple. It becomes:—

$$R = 0{\cdot}2\,\Delta^{1{\cdot}5}$$

In regard to this test the Commission Permanente de Standardisation has made the following recommendations:—

"The wear and the sphericity of the ball must be frequently checked. It shall be brought into contact with the surface of the metal to be tested by a lever, piston or spring in such a way that the pressure increases gradually and uniformly. This condition is very important; it is necessary, moreover, that the testing apparatus should be arranged in such a way that the direction of pressure is at right angles to the surface of the object tested. The surface to be tested shall be filed, and preferably polished with fine emery paper, care being taken not to produce any superficial hardening. The maximum pressure shall be taken as 3,000 kg. for steel and 500 kg. for copper and its alloys. Two diameters at right angles to each other shall be measured, preferably by means of a microscope with a measuring eyepiece, or some similar apparatus, and the average of the two measurements shall be taken. As the influence of the length of time during which the load is applied is very great, only tests for which the periods of application of the load have been exactly the same, shall be compared. When comparative tests only are made at different points on the same test-piece or on different test pieces, the pressure may be applied for any length of time. (The Artillery Specifications fix the time at 10 seconds.) When the figure of the hardness is fixed and no length of time is specified for the application of the pressure, this time shall be 15 seconds. The calibration of the testing apparatus may be effected with specially prepared metal bars on which impressions shall be successively made with the testing apparatus and with an apparatus taken as standard or with marked weights, the period of time being the same in both cases."

It is to be noted that M. Guillery has invented an apparatus which allows for rapid tests being made, the shortness of the duration of the test being compensated for by an increase in the load (*Revue de Métallurgie*, February, 1921, "Mémoires," page 101). Finally, it should be pointed out that the ball falling weight tests are not generally employed in France; the *trousse de comparaison* described by Turpin and constructed by Morin (*Revue de Métallurgie*, February, 1915, page 104) is, however, fairly frequently used when approximate results only are required.

4. *Punching Test.*—This test, which is of the greatest interest to manufacturers and users of sheet metal, has just been officially prescribed in the specification for sheet aluminium. As is well known, this test is as follows: A punch of definite shape and dimensions punches the metal, and the depth of the deflection is measured at the instant the breaking of the plate takes place. Fig. 3 reproduces one of the forms most frequently used and given in the official specification for sheet aluminium. Frémont, in a note to the Académie des

* Paper read at the summer meeting of the Institution of Naval Architects, July 6, 1922.

Sciences (January 17, 1922), has shown the inaccuracy of this method, as the moment of breaking may be wrongly judged; thus, Frémont has shown that for sheet aluminium an inspector might record a value for the deflection varying between 3 mm. and 9 mm. Very justifiably Frémont comes to the conclusion that it is necessary to introduce a recording diagram and to limit the punching to the first yielding of the plate in the case of metal sheets selected for their rigidity. Moreover, Frémont advises a falling weight cupping test in the case of metal sheets used on account of their resiliency.

5. *Wearing Tests.*—We know that the results of wearing tests are very uncertain, and also that the tests are very delicate and sometimes of exceedingly long duration. The Martens, Derihon and Amsler machines are not in general use on account of one or other of these reasons. A French engineer, M. Jannin, has constructed a very simple machine based on a new principle, which in a few minutes gives reliable results which can easily be expressed by a number (*Revue de Métallurgie*, February, 1922, "Mémoires," page 109; see Fig. 4 above). "Constructed for the purpose of determining the resistance to wear of the various metals used in the manufacture of journals and bearings, it allows of the determination of the influence of lubricating oil, of the polish of the journal, and of the hardness of the bearing, upon the wear of these parts. The principle upon which this machine is based recalls somewhat that underlying the Brinell machine. It consists in producing an impression on a small tongue of metal at the end of a comparatively short space of time through the friction of a revolving journal. This impression is sufficiently well defined to allow of its being measured and compared with other impressions produced under the same conditions.

"The machine (Fig. 4) is composed of a horizontal spindle revolving at a uniform speed. On this spindle is mounted a journal, if a bearing metal is to be tested, or a roller A, if metal for the manufacture of shafts. Above the journal or roller a small vice fixes the tongue of metal B on which the wear is to be measured. This vice is mounted on the beam C of a steel yard, in such a way as to cause the metal tongue to exert a constant pressure on the journal. The journal is adequately oiled during the test by means of an oil reservoir placed above it. The duration of the tests is generally fixed at 5 minutes for the test on bearings and 15 minutes for the test on shafts. If it is desired to make a thorough study of the various influences affecting the wear, the test must last for an hour or two. The wear depends on the following five variable factors: The material of the journal, its hardness, its degree of polish, the material forming the metal tongue and the nature of the lubricant. It is evident that if four of these variable factors are maintained constant the influence of the fifth can be determined."

6. *Alternating Tests.*—These tests relate almost exclusively to the materials of moving parts. It is, however, desirable to call attention to the conclusions to be drawn from several definite results obtained with the well-known Cambridge machine in which repeated blows are directed on a test-piece rotating about its axis. Systematic tests carried out on different materials, ordinary and special steels, brass, aluminium bronzes, light alloys and especially materials and alloys of identical composition which have undergone different mechanical treatment, prove the great importance of the limit of elasticity from the point of view of resistance to these repeated light blows (Guillet, *Revue de Métallurgie*, February, 1921, "Mémoires," page 96, and December, 1921, "Mémoires," page 755). It is evident that too much attention is given to the question of high resiliency, and that in consequence a lowering of the elastic limit is too readily permitted, although the latter has a very important effect on the wear of parts, the majority of parts requiring only a moderately high tensile strength (12 kg. to 15 kg. per square centimetre).

Macrography.—Macrographic investigation is not yet generally used as a method of testing. This is a serious mistake. It ought to be very widely employed and be looked upon as a workshop method. It requires neither the very special apparatus of micrography, not unusual care in the preparation of test pieces, nor even specialised knowledge for the interpretation of the results. Amongst these results must be cited segregation, heterogeneity, the existence of blowholes, more especially in metallurgical materials. The iodo-iodide reagent of Frémont, the methods of recording on photographic bromide paper the presence of sulphur and phosphorus, the Stead-Le Chatelier or copper chloride reagents, are worthy of the attention of all those who use blast furnace products. Macrography allows of the detection in a very rapid and simple manner of very important and common defects.

Physical Tests.—Hitherto physical tests have been regarded as delicate laboratory operations. We should like to call attention to two of these tests which may be very effective in certain cases. M. Galibourg has recently shown (Reports to the Académie des Sciences, February 6, 1921) the advantages which can be derived from using thermo-electricity. Two steels may present practically the same degree of Brinell hardness although differing materially in composition, the one for example containing 0·3 per cent. C and 3 per cent. Ni, the other 0·1 per cent. C and 6 per cent. Ni. A thermo-electric investigation permits of these two steels being differentiated by comparison with a standard metal, a mercury bath, slightly heated, very rapidly ensuring contact between the material to be tested and the standard metal, and the current passing through a galvanometer (Fig. 5). Chevenard has constructed a new dilatometer which is very strong and can be safely handled by anyone. By means of this dilatometer the points of transformation can be found, and it is thus possible to identify the different casts, at least for special steels. For this purpose the metal under test is bored in the centre and placed in a heated silica tube (Fig. 6, annexed) (*Revue de Métallurgie*, January, 1922, "Mémoires," page 39); a needle of an alloy (pyros) following a known and regular law of expansion is placed in the central hole; one rod of silica rests on the pyros and a second on the metal itself; the movement is magnified by levers and finally the curve of the temperatures and also the curve of the expansions of the metal are registered on a cylinder rotating at a uniform rate. The irregularities are noted, and by comparing them with the first curve the position of the points of transformation is known.

Fig. 3. APPARATUS FOR PUNCHING TEST

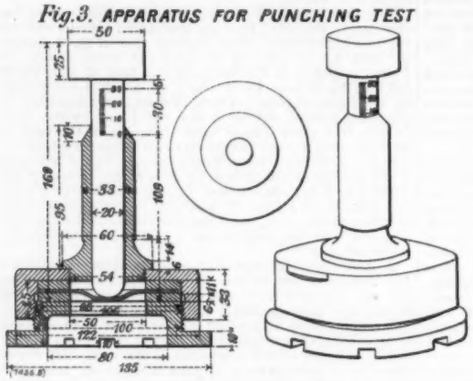


Fig. 4. APPARATUS FOR WEARING TEST, JANNIN SYSTEM.

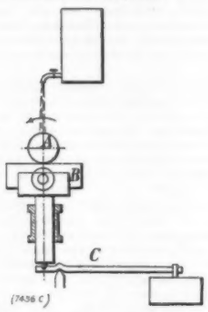


Fig. 5. APPARATUS FOR THERMO-ELECTRIC TEST.

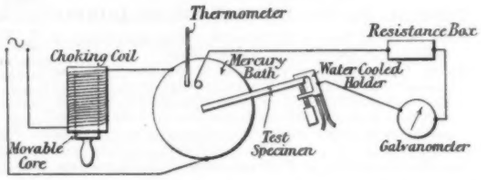
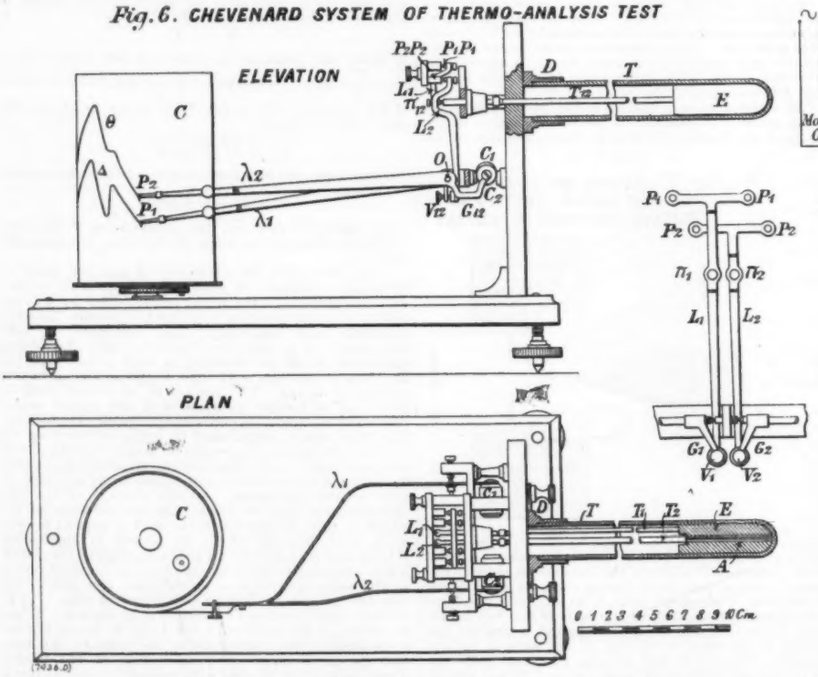


Fig. 6. CHEVENARD SYSTEM OF THERMO-ANALYSIS TEST



Conclusions.—This paper has been intentionally limited to an account of the most recent methods of testing, excluding those methods which come purely within the region of research work. It will be seen that the user of metallurgical materials has within his grasp all that is necessary in order to obtain quick and accurate information regarding their value.

QUESTIONS REGARDING THE DESIGN AND ACTION OF REDUCTION GEARS.*

By JOHN H. MACALPINE.

I HAVE great pleasure in responding to the gracious invitation of the Association des Ingénieurs, Liége, to contribute to the work of the Congrès Scientifique, held to commemorate the seventy-fifth anniversary of the foundation of this distinguished association. I trust that from this meeting will date another long period of usefulness, and pray that it may be destined to pursue its course amid profound peace and goodwill and with ever-increasing prosperity and benefit to mankind.

Recently I have had occasion to study again many important papers, discussions and editorials, on the subject of reduction gears, which forms the most remarkable recent advance in engineering science. In the invitation to contribute this paper there is a kindly reference to my own previous writings on the subject, papers which I feared had largely failed to attract serious consideration, but I am gratified to find from this reference that I am partially in error. I pointed out a path which has been followed to some extent in America and Japan, but has only recently found an opening in Europe. From the first I warned against the great redundancy and consequent imperfection of action of the rigid gear—that is, gears which have the pinion and gear wheel bearings all rigidly held in the housing. These difficulties can hardly be said to have been experienced at that time, as reduction gears of high power and speed, so common now, had not then been built. They have since been experienced very generally, accounting for the relatively low load at which rigid single-reduction gears can be run and the now well-known and appalling trouble affecting double-reduction marine gears which, as one gathers from recent writings, amounts in Britain almost to a national calamity.

I intend to present for your consideration a brief discussion of the questions in which I have always differed from advocates of rigid gears and to point out again the origin of the troubles to which I have just referred; and how, having been clearly foreseen, it was proposed to avoid them by the adoption of the floating frame patented by the late Rear Admiral

* Paper read before the Association des Ingénieurs, at Liége, at the conference held in June, 1922.

George W. Melville, Ex-Engineer-in-Chief, U.S.N., and myself. Such discussions are scattered through my former papers, but it may be useful to gather them together here.

Very strangely and persistently the common belief still is that the floating frame was devised to counteract the detrimental effect of bad tooth cutting. I wish to state once more, emphatically, that no device can do this,* and it was no part of the object of the floating frame. The sole object was to produce good running contact of the teeth and a practically uniform distribution of pressure along all the tooth face, even if there were very sensible misalignment, which should be anticipated, and is practically sure to happen in the life of every gear. All through the papers on rigid gears which I have recently re-read one cannot fail to observe that the question of alignment is the one dominant note, continually recurring—its delicacy; the care which must be exercised to secure it; the necessity for double checking in shop and ship insisted on by the British Admiralty; the care necessary in the design of the gear housing and keelsons, in the vain hope that it may not be upset; the observation of the warping of the gear housing through the working of the ship in a seaway, causing serious misalignment; the demonstration of the misalignment of many rigid gears after they had been some time in operation. One may turn to any writing on the subject in the last ten years to verify this statement. To quote all the passages bearing on the subject would require the transcribing of a very considerable percentage of all this literature. The only omission is that of a single practical suggestion to overcome this difficulty. It will always be present with rigid gears. It can only be overcome by removing both the necessity for extreme accuracy of alignment and the dependence on the necessarily non-rigid housing. As the floating frame accomplishes these we can safely load a gear and pinion of given dimensions far beyond the safe load were they rigidly mounted.

I presume that the design of the floating frame is so well known that I need not take space to figure it here. The reader who is unfamiliar with the device is referred to the article in ENGINEERING, vol. lxxxviii, page 377. This explains the principal function of the floating frame and shows its design in the experimental gear, tested in 1909, soon after this article was published.

I shall present the subject under the following heads: (1) The Power Constant; (2) Two Discrepant Rules for Determining Tooth Pressure; (3) The Delicacy of Alignment and Redundancy of Rigid Gears; (4) The Present Difficulties with Double-Reduction Gears.

1. *The Power Constant.*—There is a simple and well-known law connecting the loads and stresses in all similar machines where gravity is not an important element. Suppose, for definiteness, that we have two similar gears, of the same materials in corresponding parts, one of which has the linear dimensions twice those of the other. In order to eliminate, for the present, consideration of the action of the lubricant, we will suppose them under load but at rest.

To stress the shafts actuating the pinions to the same intensity, the torque applied to the larger will have to be $2^3 (= 8)$ times that applied to the smaller, as it is only half the diameter. That is, if we suppose the torque applied by forces at the ends of two similar cranks, the load or force applied to the crank-pin of the longer will be four times that applied to the crank-pin of the shorter. Thus, these loads are proportional to the squares of the linear dimensions.

The torques are communicated to the driven ends of the pinions which have also the same relative diameters, and consequently the same intensity of shearing stress is induced in each. These torques are resisted by the tooth pressures and, as this in the larger pinion acts at twice the leverage from the pinion axis, the total tooth load is four times as great as for the small pinion. Again, as the tooth face of the larger pinion is twice that of the smaller the pressure per inch of tooth face is twice as great as that of the smaller pinion. That is, the tooth pressure per inch is proportional to the pinion diameter.

Next, consider the cross-bending of the teeth. For corresponding lengths of tooth face we have just seen that the corresponding tooth loads are in the ratio of 4:1. The leverages are as 2:1; so that the cross-bending moments at any section are as 8:1. But in the larger pinion the sections, being of twice the linear dimensions, are eight times as strong as in the smaller pinion, and the intensity of tension and compression induced is, therefore, the same in both. The same result would be arrived at if we considered any corresponding portions of the whole gears, including the housing, or if we had supposed any other ratio of linear dimensions. As the intensity of stress at all corresponding points is the same, it follows at once that the deformations are proportionate and that similar gears will remain similar under corresponding loads.

Considering the whole matter more fully I set down the following fundamental propositions* :—

Proposition B.—In any similar machines with similarly-applied loads in proportion to the squares of the linear dimensions, and in similar configurations :—

(*a*) The intensities of internal and surface stress at corresponding points are the same; also

(*b*) The distortions are proportionate, so that, taking account of these, the configurations remain similar.

Proposition C.—In any type of design of reduction gear there is one set of proportions which is better than any other.

As the pinion is many times more elastic than the large gear wheel, the stress it can be submitted to without undue bending or distortion determines the safe load the gear will bear. The safe load, applied at the end of the crank in the foregoing illustration, being proportional to the square of the linear dimensions, the torque applied to the pinion is proportional to the cube; also, if the pinion now revolves the power transmitted will be proportional to this torque and the revolutions per minute jointly. Thus:

$$P = \text{constant} \times D^3 R, \text{ or}$$

$$\text{Constant} = \frac{P}{D^3 R};$$

Where P = the horse-power transmitted,
D = the pinion diameter in inches,
R = the revolutions of the pinion per minute.

Multiplying this constant by 1,000, to make the value fall usually between 1 and 10, we may write,

$$\text{Power constant} = C = \frac{1{,}000\ P}{D^3 R}$$

But all gears are not similar. A change in the diameter of the large gear, the addenda and dedenda of the teeth remaining the same, will make only a negligible change in the length of the arc of contact. It will also change the size and elasticity of the housing, which, for floating-frame gears, as they are little affected by this slight elasticity, is not important. Rigid gears, being seriously affected by any yield of the housing, do not use the power constant. I will deal much more fully with this further on.

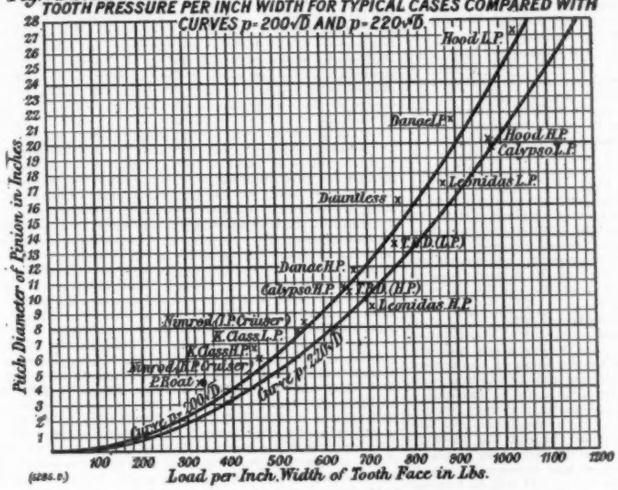
Also the ratio of tooth face to pinion diameter may be changed. As this is increased the cross-bending and torsion of the pinion increase. When the tooth face is short these yields are negligible and the power transmitted without lowering the factor of safety is nearly proportional to the length of face. But as the face lengthens we reach a value at which the safe load is a maximum; when this is far exceeded the yields will be so large that there will be serious concentration of tooth pressure and the safe power will decrease. But for a considerable range near the above maximum, the tooth length may be varied with little change of the safe load.* Calculation seems to show‡ that for a three-bearing pinion and floating-frame gear a tooth face of about four pinion diameters gives this maximum.† For a rigid gear or a two-bearing pinion this ratio will be smaller. In the floating-frame gears built by the Westinghouse Electric and Manufacturing Company the ratio adopted is usually about 4.

2. *Two Discrepant Rules for Determining Tooth Pressure.*—It is quite obvious from the foregoing that, if we may neglect the action of the lubricant, the tooth pressure per inch face may be raised in proportion to the pinion diameter, for similar gears—that is, supposing the gears, if rigid, to be in line; but for floating-frame gears, whether they are quite perfectly in line or not. This will keep the value of power constant unchanged in these similar gears. If the ratio of tooth face to pinion diameter is decreased from the value of about 4, the safe tooth pressure will rise somewhat and the power constant fall, at first very slightly but at an increasing rate. For simplicity we will neglect this here; that is, we will suppose a nearly constant value of this ratio.

Experience has fully demonstrated that much higher power constants can be used with the floating frame than in rigid gears. U.S.S. Collier Neptune's gears had a mean power constant of 5·22 on her official 12-hour, full-power trial, in 1915; and this ship has seen very much service since with power constants ranging, during long periods, from 4·3 to 5·3. The last report I received was about one year ago when the teeth were in excellent condition showing little sign of wear. On other marine gears values very frequently run from 3 to 4.

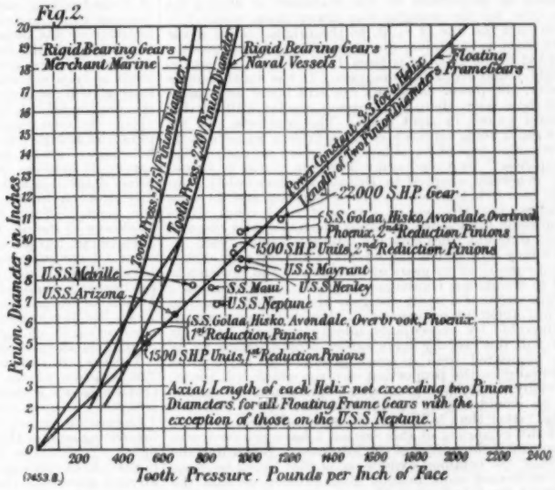
I have calculated‖ the power constants from the rigid gear data given by Commander H. B. Tostevin, D.S.O., R.N., for British warships.§ The maximum is 2·568; the average for the high-pressure pinions 2·07; and the minimum for these 1·424. The average power constant for the low-pressure pinions was much smaller, as these for the ships he includes in his table were, with two exceptions, made of larger diameter than the high-pressure, to give a slower speed low-pressure turbine. As merchant ships have to run a large proportion of their time near full speed and warships only a small proportion, the power constants for the rigid gears in the former are usually a good deal smaller than for the latter. Also, wide experience clearly indicates that as the size of the rigid gear increases the power constant must be lowered. This has led to the adoption of an empirical rule, $p = K\sqrt{D}$, where p is the tooth pressure per inch face and D the pinion diameter. As shown above, in similar gears the stresses are the same at corresponding points if the power constants are the same, and the tooth pressure per inch then rises as the pinion diameter, or $p = K_1 D$. It follows that the $\sqrt{D}$ rule gives rise to lighter and lighter stresses as the size of the gear is increased. To present graphically data on rigid and floating-frame gears I will reproduce two diagrams. Fig. 1 is from Commander Tostevin's paper and exhibits the data for British warships.‖ Fig. 2 is from a paper of mine discussing Commander Tostevin's paper and a later article in ENGINEERING.¶ The curved lines are obviously parabolas tangent at the origin to the line of D = 0. Though of different scale the diagrams are easily compared as the curve having K = 220 is given in each. One case in Fig. 1, that for Leonidas H.P., gives K = 226; in all others K is smaller and, in not a few cases, less than 200. In Fig. 2 the straight line exhibits the rise of the value of K as the size of the gear increases, the power constant being 3·3 and the tooth face four pinion diameters. The data plotted is for floating-frame gears of war and merchant ships. In all these ships K is over 220 and, for most of them, far over. Comparison of Figs. 1 and 2 shows that while the power constants of rigid gears fall as the diameter of pinion increases—

Fig. 1. DIAGRAM ILLUSTRATING THE RELATION BETWEEN P.C.D. OF PINION AND TOOTH PRESSURE PER INCH WIDTH FOR TYPICAL CASES COMPARED WITH CURVES $p = 200\sqrt{D}$ AND $p = 220\sqrt{D}$.



(5285.8.)

Fig. 2.


Rigid Bearing Gears Merchant Marine
Rigid Bearing Gears Naval Vessels
Floating Frame Gears
Tooth Press. 175 Pinion Diameter
Tooth Press. 220 Pinion Diameter
Power Constant = 3·3 for a Helix Length of Two Pinion Diameters
22,000 S.H.P. Gear
S.S. Golaa, Hisko, Avondale, Overbrook, Phoenix, 2nd Reduction Pinions
1500 S.H.P. Units, 2nd Reduction Pinions
U.S.S. Melville
U.S.S. Arizona
U.S.S. Mayrant
U.S.S. Maui
U.S.S. Henley
U.S.S. Neptune
S.S. Golaa, Hisko, Avondale, Overbrook, Phoenix, 1st Reduction Pinions
1500 S.H.P. Units, 1st Reduction Pinions
Axial Length of each Helix not exceeding two Pinion Diameters for all Floating Frame Gears with the exception of those on the U.S.S. Neptune.
Pinion Diameter in Inches
Tooth Pressure. Pounds per Inch of Face

(7453.8.)

* See ENGINEERING, vol. ci, page 491.

* See ENGINEERING, vol. ci, page 416. I omit Proposition A as it is less general than Proposition C.

* See Trans. Inst. Engineers and Shipbuilders in Scotland, vol. lxi, page 347.

† See ENGINEERING, vol. ci, page 457.

‡ See ENGINEERING, vol. cxi, page 611.

§ See ENGINEERING, vol. cix, page 476, Table I.

‖ See ENGINEERING, vol. cix, page 478.

¶ See ENGINEERING, vol. cxi, page 611.

that is clear, as the curve for K = 220 falls further and further short of the straight line for C = 3·3—those for floating-frame gears show no such decrease. Further, the power constants for floating-frame merchant ships—even those for second-reduction pinions, which have given so much trouble in rigid gears—are much larger than in British warships. (It may be explained that the Neptune's tooth face is 5·15 times the pinion diameter, which accounts for her circle falling so much farther to the left than might be expected from her high power constant. For all the other ships this ratio does not exceed 4; that is, each helix length is not over two pinion diameters, as noted in Fig. 2.)

The fall of power constant is so great in larger rigid gears that, as I show, those of H.M.S. Hood could with perfect safety have been built on half the weight by adoption of the floating frame.* The rigid gears of the S.S. Cameronia are properly claimed as highly successful.† Her second reduction pinion is 25 in. diameter and its power constant, at full power, 1·396 if the tooth face is 100 in.; if narrower, the power constant is proportionally smaller. The tooth pressure is therefore exceedingly small and the weight very unnecessarily great.‡

Fig. 2 shows that if the $\sqrt{D}$ rule were followed down to small values of D, the power constant would rise to 3·3 at D a little over 4 and K = 220. As D still farther decreased the power constant and stresses in the gear would increase indefinitely. Thus the $\sqrt{D}$ rule must be abandoned for small diameters. The rule of the Parsons' Company is stated§ as making K "between 180 and 220, unless lower values are specially requested" for pinions down to 10 in. diameter. Below this the pressure is reduced in proportion to the diameter, as shown for K = 220, by the straight line drawn from where this curve cuts the line D = 10, to the origin. Thus if the tooth face is 4 pinion diameters the power constant adopted below D = 10 is from 1·81 to 2·21, as can be readily found from the diagram. If the tooth face is shorter, the power constants are still lower and, as I shall show later, there is an urgent cry for still further reduced values in rigid gears. The complete rule for rigid gears being represented by a broken line evidently expresses no true physical law. It is very properly called "empirical" by Commander Tostevin;‖ and as it was very generally adopted in Britain we may safely conclude that it is founded on wide experience and involves a radical imperfection of action of rigid gears. This remarkable divergence of power constants and the two widely different rules calls for careful consideration.

We may at once eliminate faulty tooth cutting, as that would equally affect gears of both types, and principally lead to anomalous results among gears of the same size; for the errors of a badly-cut gear are so small that they are not apparent on inspection though to some extent discoverable by exceedingly minute gauging. A large gear will not usually have errors proportionate to its size, compared with a small gear; and as it must principally be the proportion of error which will count, especially if the large gear is run with a slightly thicker oil, we would expect to find the safe power constant rising, rather than falling, as the size increased.

At the beginning of this section I have reserved consideration of the action of the lubricant. Regarding the bearings, the common experience is that larger bearings may be loaded more heavily than smaller, so that the action of the lubricant in them would also rather allow of a rise of power constant as the gears increase. The lubrication of gear teeth is investigated in ENGINEERING vol. cii, page 119. It is concluded that "so far as security against abrasion is concerned, it would seem that the permissible load per inch of pinion length will vary with the square root of the pinion diameter." On page 527 of the same volume I point out two considerations omitted from the investigation which would modify the conclusion and make the safe pressure rise approximately as the first power of the pinion diameter. It follows from the foregoing Proposition B, that in similar gears under corresponding loads, that is with the same power constants, the breadths of the extremely narrow strips of the teeth in contact, usually described as the lines of contact, are proportional to the linear dimensions. And as the tooth pressures per inch face are also proportional to the linear dimensions the intensities of pressures per square inch for the larger and smaller gear are the same. Moreover, the broader strip of the larger gear will more securely entrain the oil; so that, even with the same lubricant, the safe pressure should apparently rise a little more rapidly than the linear dimensions. This supposes perfect alignment. As some of the tooth errors will usually be greater in the larger gear, this more rapid rise may be discounted a little; but, as already pointed out, tooth errors will rather give rise to anomalous results than affect the law deduced from experience for well-cut gears. I was pleased to note the conclusion, reached later in ENGINEERING, vol. cix., pages 599 and 601, based on later researches, "that the load imposed on the teeth should vary directly as the diameter of the pitch circle and not in proportion to the square root of this diameter."

There seems to have been considerable investigation of the action and rupture of the oil film in gear teeth besides that noted above; as, for instance, is indicated by Mr. H. L. Guy in the discussion of Commander Tostevin's paper.¶ A number of others have also referred to it, speculating on the trouble, experienced by rigid gears, being due to the limiting pressure having been reached, above which rupture would occur. That seems almost self-evident; but as floating-frame gears run safely at much higher pressures than rigid gears, we may be sure that in the latter the pressure has been localised by misalignment, giving a maximum pressure far exceeding the designed mean. I will give evidence later, putting this beyond doubt. The Westinghouse Electric and Manufacturing Company have always used the power constant in designing floating-frame gears, and this practice, long in force, now forms a strong body of evidence that it is the correct rule for gears with good tooth contact.

I regret that in the sequel I will frequently have to use K, thus apparently recognising the validity of the misleading empirical $\sqrt{D}$ rule, the introduction of which has greatly hampered clear thinking. But published rigid gear data is expressed by means of it, and it will be found to lead to quite conclusive comparisons.

3. *The delicacy of Alignment and Redundancy of Rigid Gears.*—In the previous section I have eliminated both imperfect tooth cutting and lubrication as fundamental causes of the low power constants of rigid gears and the adoption of the $\sqrt{D}$ rule. Only the question of misalignment and its causes are left. As I noted earlier, "alignment" is the ever recurring source of discussion and disquietude in all writings on rigid gears.

Suppose a rigid gear perfectly machined, the axis of the bearings of the gear being exactly parallel to that of the pinion and at correct centres. When the gear and pinion are now put in place, the teeth will mesh perfectly. If put under load they will still mesh perfectly and bear evenly all along, except for the usually slight effects of cross-bending and torsion, if we may suppose the housing to be perfectly rigid. But let one of the two bearings of the large gear be lowered $\frac{1}{10}$ in. by wear, or warping of the housing from any cause. We would at once produce point contact, for the flexure of the teeth is very minute. Even in a large gear under full load it will be much below $\frac{1}{1000}$ in.* The action of the double-helical teeth would, as is well known, still divide the load equally between the two helices, as the pinion is always left free to move axially; but in both helices we would have nearly point contact and an enormous increase in the maximum load of the teeth. Even if there is a bearing of 75 per cent. of the tooth face, the maximum tooth pressure is about 2·67 times the mean.† Some believe that the variation of the thickness of the oil film in the bearings allows valuable adjustment, but the oil film is very much thinner than the error I have supposed; also, the adjustment supposed to be made under changing journal pressure clearly predicates a changed and, consequently, uneven distribution of tooth pressure; further, Professor Osborne Reynolds' investigations show that the oil film is very insensitive to change of pressure.‡ This completely eliminates all valuable help from the oil film.

We are left with two quaint independent conditions: The position of the pinion axis which gives uniform tooth pressure is determined by the teeth of the pinion and gear; it must coincide with the axis of the bearings. This coincidence can only be brought about by extremely fine fitting and, as the housing is elastic, it is very readily upset. It would be wearisome to the reader to give the multitude of cautions scattered all through the writings on rigid gears as to the extreme care which must be taken to secure this alignment. Almost any paper will furnish them in abundance. The only thing that will be hunted for in vain is a possible method of keeping the alignment after it is attained.

On the other hand, in a floating-frame gear, if one of the bearings of the main gear is lowered the pinion and floating frame follow. For instance, on one of 34 United States destroyers of 27,000 h.p., a bearing of the main gear burned out and the bearing went down $\frac{7}{16}$ in. No harm was done.§ The elastically mounted pinion simply accommodated itself.

Also if, instead of vertical misalignment there be horizontal, it can readily be shown that this is perfectly compensated by a slight angular yield of the floating frame in the vertical plane; the combined vertical and horizontal rotations of the floating frame giving a resultant rotation about an axis parallel to the line of action of the teeth. This displacement may be safely carried far beyond what would ever occur in practice. I have explained this so often that I think I need not devote here the considerable space which would be required.‖

The floating frame thus makes us practically independent of any cause of misalignment whether arising from wear of the bearings or straining of the housing. This straining may arise from a number of causes, such as gradual change of the internal strains, elastic yield under varying load, slackening or adjustment of the bolting, or warping of the ship, &c., all of which would seriously affect the alignment of a rigid gear. Hence the safe power constants could not fail to be much higher in the floating-frame gear.

But this does not account for the rigid gear safe power constant falling as the gear becomes larger, as indicated by the $\sqrt{D}$ rule and shown clearly in Fig. 2. From Proposition B it should be possible to load similar gears to the same power constant. The obvious reason is that large gear housings would be exceedingly massive if made similar to those of small gears. Thus the gears are rarely similar, the large gears have relatively much more elastic housings, and the safe power constant is, consequently, lower.

If this is correct, then the much larger housings required to accommodate a double reduction in a single casing should necessitate a still lower power constant for a rigid gear. After experience with single reduction had settled the values of K which might be used with success in rigid gears, double reduction was introduced adopting these same values, with most unfortunate results, and it is very surprising that there has been so much futile speculation as to the cause—which lies on the very surface. Further, there should be no necessity for the lowering of the load in a double-reduction floating-frame gear, if the action is nearly independent of the elasticity of the housing, and Fig. 2 shows that this has not had to be done. As it is with double-reduction gears that the disaster referred to has principally occurred, I will treat it more fully in the next section.

I was much pleased that in the discussion on my Naval Architects paper, Sir William E. Smith clearly perceived that the object of the floating frame was to remove the geometrical restraint which gives such a pronounced redundancy to the rigid gear, as I have shown. He refers to the removal of these restraints from the design of instruments of precision as the teaching of that great scientist and inventor, Lord Kelvin, as I well remember. Later in the same discussion Sir William says "There cannot, however, be any doubt that the floating bearing does remove a very serious possibility of trouble arising through imperfect workmanship, or imperfections, possibly arising from the straining of the ship or through accident."* I will also quote from my friend Dr. R. F. Muirhead: "Messrs. Melville and Macalpine had the merit and good fortune to perceive that one of the chief difficulties of constructing a satisfactory reduction gear for large powers in a confined space could be overcome by getting rid of a redundant constraint. He could well remember Lord Kelvin expounding in the Natural Philosophy class-room his theory of 'geometrical constraints,' inveighing against the unscientific redundancy of constraint commonly used by instrument makers in the design of their instruments, and pointing out the benefit of making constraints sufficient and no more. An old pupil of Lord Kelvin, Mr. Macalpine, had applied the principle of 'geometrical constraint' to a problem which had not arisen in Lord Kelvin's time,† and had done so in a thoroughly practical way, by giving the pinion shaft a certain amount of freedom, not only of translation along its own axis, but also of rotation about a transverse horizontal axis, and so securing not only equal pressures on the teeth of the two pinions, but also approximately uniform pressure on each tooth."‡ These are two of, apparently, a very small number who perceived the real nature of the invention, though I had taken great pains to make it clear and it is certainly exceedingly simple. That it was not generally grasped at once, and is not even now, has been an inexplicable surprise to me.

Very curiously, Sir Charles A. Parsons, in his first published attack on the floating frame, stating that it seemed to him that there was no good reason for using it, says that the end motion of the pinion is sufficient adjustment—quite overlooking the great redundancy.§ How can a pinion, if held out of line by its bearings, be put in line by end motion? Trouble from synchronous vibration, due to the floating frame, which he says "one would imagine," has never been experienced; the marking of the large gear in zones, equal in number to the blades of the propeller, which has caused such great trouble with rigid gears.‖ has not once been observed.

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* See ENGINEERING, vol. cxi, page 611.
† See ENGINEERING, vol. cxii, page 311.
‡ See ENGINEERING, vol. cxii, page 660.
§ See ENGINEERING, vol. cix, page 369, and vol. cxii, page 167.
‖ See ENGINEERING, vol. cix, page 477.
¶ See Trans. Inst. Naval Architects, vol. lxii, page 143.

* See ENGINEERING, vol. cxi, page 610.
† See *ibid.*
‡ For a fuller discussion of the subject, see ENGINEERING, vol. cxi, page 611. The reference given as "(600, Fig. 2)" should be "(vol. cix, page 600, Fig. 2)."
§ See ENGINEERING, vol. cxi, page 641.
‖ For instance, see ENGINEERING, vol. ci, page 479—"Errors of Alignment."

* See Trans. Inst. Naval Architects, vol. lix, pages 165 and 166.

† To show Lord Kelvin's wide interest and for its historical value I quote from a letter, now before me, written from London by Mr. George Westinghouse to Admiral Melville on August 20, 1906: "The occasion of this letter is to tell you of my coming and also to give you a quotation from a letter just received from Lord Kelvin, which is as follows: 'I have been hearing from a naval expert here that probably the transatlantic steam-turbine ships use as much as 15 lb. steam per horse-power hour! Do you think it possible to use gearing, satisfactorily in practice, so as to utilise your turbines running 3,000 r.p.m. or 3,600 r.p.m. and get down speed to suit the screw propellers, and use only 10 lb. steam per horse power hour?'" That one so far removed from this field as Lord Kelvin should at once appreciate the proper direction in which to seek a solution, shows the fertility of his genius.

‡ See Trans. Inst. Engineers and Shipbuilders in Scotland, vol. lxi, page 375.

§ See Trans Inst. Naval Architects, vol. lii, page 181; see also vol. liii, Part II, page 120.

‖ See ENGINEERING, vol. cxi, page 369, and vol. cxii, page 363. Messrs. Walker and Cook devote the latter part of the Naval Architects paper to a slight discussion of torsional vibration of propeller shafting in rigid-gear ships. The large part of the difficulty obviously arises from the rigid connection of the turbine to the gearing, and from the great energy of rotation of the turbine. The propeller shaft is the most flexible part of the mechanism, and they quite wrongly state (vol. cxi, page 370) "to provide this flexibility in any other way is almost impracticable."

The destructive criticisms of the floating frame by Sir Charles Parsons and his associates, with which I am dealing in this portion of my paper, one would naturally understand to be the frank statement of unbiased judgments arrived at after careful study. Study of published floating-frame designs shows at once that this flexibility has always been supplied, quite simply, by an elastic shaft between the turbine and pinion. As I state in the text, it has been quite effective in preventing any noticeable torsional vibration in floating-frame gears and a vexatious and costly difficulty has thus been

Again, he states that "such devices as floating frames for the pinions . . . are totally unnecessary, the natural elasticity of the supporting structures providing all the accommodation necessary, assuming, of course, reasonably accurate alignment of the shafts."*

Surely Sir Charles' phrase "reasonably accurate alignment" is wholly misleading. Messrs. Walker and Cook state "The authors are of the opinion, however, that the most important factors in successful running of gears are accuracy in manufacture, which includes in particular the *cutting of teeth* and *correct alignment*. These two points cannot be too strongly emphasised."† This is a worthy statement, and I have no doubt that the italics they use were suggested by much painful experience. It is in line with the expressions of all others except that just quoted from Sir Charles. It should be remarked, however, that the necessity for correct alignment does not end in the shop or on installation in the ship—the British Admiralty recognising its great liability to change insist on the second check in the ship.‡ It has no value unless maintained in operation. This essential condition, Messrs. Walker and Cook suggest no solution for. Later, Mr. Cook makes the statement§ "The question of obtaining the necessary accuracy of alignment was one of careful workmanship and reasonable care. If good distribution could be obtained in that way there was obviously no necessity for the floating frame." If, on the other hand, good alignment could not be *maintained*, as I will show in the next section, does not the opposite conclusion become obvious? Mr. Cook proceeds, "He was, however, in full agreement with Mr. Narbeth and Mr. Freeman that there was no palliative for inaccuracy to be found, in the floating frame or any other device." This is only one of the many expressions suggesting that the floating frame was put forward as such a palliative. The opinion has no foundation in any writing of mine and I have combatted it since I first saw it. Before placing the order for cutting the teeth of the first large high-speed reduction gear ever made and tried, that of floating-frame type tested by Mr. George Westinghouse in 1909, with a success which thrilled the engineering world, we wrote to Messrs. Schuchardt and Schutte, July 23, 1907, "Would it be possible, with your gear-cutting machine, to finish these teeth, either by milling or grinding, with a maximum error well within $\frac{1}{2500}$ in.?" They assured us of absolute accuracy. It will surely be understood from this that we placed no dependence on the floating frame to correct imperfect tooth cutting.

Mr. Cook's statement that there was no palliative for inaccuracy is at variance not only with Sir Charles Parsons' statement, quoted above, regarding the beneficial effects of elasticity "of the supporting structures," but also with what he said only last year when again condemning the floating frame, "that the elasticity of the material of the gear itself and the gear-case is quite sufficient to accommodate unavoidable initial errors when the gear is new."‖ It is also contradictory of Messrs. Walker and Cook's judgment in their Naval Architects' paper last year—"The flexibility of the pinion shaft, along with the structural flexibility of the gear-case and teeth may, however, have some value in reducing fluctuation of higher frequency, such as might arise from irregularities in the teeth."¶ Mr. Walker, in discussing a paper of mine, sees some indefinite advantage—"Mr. Macalpine seemed to lay undue stress on the uniform distribution of tooth pressure by the adoption of the floating frame as compared with what he termed the 'rigid' gear. He [Mr. Walker] thought that the word 'rigid' was somewhat a misuse of the term, as these gears were not absolutely rigid; there was always a certain amount of natural flexibility in all such structures."**

It would be interesting to know what Sir Charles and his associates do believe, for in the foregoing they have expressed quite a variety of conflicting views, aimed principally at condemnation of the floating frame. On the whole their faith usually rests in the elasticity of the gear and housing—the one thing which has been by far the principal cause of the present gear trouble. Other writers are clearer in their views. For instance, Mr. R. J. Butler, in the discussion of Commander Tostevin's paper, referring to the necessity of accurate alignment "emphasises the necessity of meticulous accuracy, involving massive construction to ensure rigidity and highly-skilled workmanship, with their accompanying expense."††

4. *The Present Difficulties with Double-Reduction Gears.*—I have referred to this in the foregoing as a disaster, after carefully studying all the published writings on the subject which have come into my hand. To give the many quotations I have noted would be very tedious, though some references must be given below in this discussion. The facts are notorious and have been the subject of acute discussion for two years or more. If anyone thinks that I exaggerate let him read the discussions of the two papers by Messrs. Walker and Cook, read last year before the Institution of Naval Architects and the Engineering Conference of the Institution of Civil Engineers;* an article in ENGINEERING, vol. cix, page 599; another in ENGINEERING, vol. cxi, page 427 (see the last paragraph, page 428); and a long note in the Journal of the American Society of Naval Engineers, vol. xxxiii, page 568, on "Double Reduction Gearing."† We read that "a large number of high-powered vessels are being forced to run at fractional powers," and this is confirmed by Captain Onyon and Mr. Butler, who have seen nozzle control valves locked; of superintending engineers in Britain having "got the wind up" badly; of ENGINEERING's demand for full information and discussion as the only hopeful path to success. Messrs. Walker and Cook state that, in view of these troubles, some shipowners desire still lower tooth pressures.‡ That the situation, in spite of optimistic predictions by Messrs. Walker and Cook, is becoming still more acute is indicated by a private letter I received from Britain recently, which says: "I understand that the situation with regard to turbines and gearing generally in this country, has undergone a complete change, a number of big superintendents actually talking about going back to quadruple expansion engines with superheat. At least one big shipping line has cancelled recently a number of big turbine sets, following on the poor success they have obtained recently with turbines." Messrs. Walker and Cook's papers are far from reassuring and several make remarks on the meagre amount of information they supply. As Mr. Butler, in discussing their Naval Architects' paper, remarks, it "partakes very much of the nature of an appologia for double-reduction gearing, and is more remarkable for what it does not contain than for what it does." The authors state in both these papers that "Several vessels with double-reduction gearing are now in service giving very satisfactory results!" There are very many such ships in Britain alone. They tabulate data of five years—six ships, as two are sister ships—with values of K from 195 to 238, two of which at least had given serious trouble from torsional vibration. When Captain Onyon invites them to "tell us what vessels with coefficients of 220, which they now advocate as a maximum, have made successful voyages of, say, 20,000 miles, steaming at their full service power,"—a request endorsed by Sir John Biles—they can only cite the Danier as having sailed over 50,000 miles with K = 239, adding that the sister ships Andalusier and Aster have done a considerable amount of steaming at the same load.§ In reply to this request I took the liberty of giving the data of 17 ships with floating-frame gears which had values of K from 260 to 220 in the second-reduction pinion, and which had sailed from 56,000 miles to 120,000 miles. The principal trouble has occurred in the second-reduction pinion of rigid gears, but in those I have just cited only one gave trouble, and that due to bad material. Indeed, it is the only second-reduction pinion of a floating-frame gear in which teeth have broken. After replacement, no further trouble was experienced. So far as the values of K are concerned, I could have greatly extended this list and many more would have had long sailing distances to their credit, but for the fact that so much American shipping has been laid up for a long period for want of cargoes. These values of K have been maintained at sea, and all of the 226 double-reduction floating-frame merchant ships are either in commission or ready to go in commission when cargoes are available. The geared turbines have been removed from one, but this was on account of turbine trouble.‖

It will be remarked that, in great contrast to rigid gears, the tooth pressures do not require reduction in passing from single to double-reduction gears. This is also shown by Fig. 2. What is the reason for this great divergence?

Messrs. Walker and Cook in their Naval Architects' paper carefully discuss all the details in which they think single and double-reduction gears, differ, in the hope of finding the source of the trouble. But they admit that they "see no reasons why double-reduction gearing should be less satisfactory than single reduction." There must be such a reason, for it has proved itself notoriously so with rigid gears. They omit altogether, what surely is most obvious, the increased flexibility of the larger housing. This makes it easier to upset the alignment. I have shown that recognition of the whole question of elasticity and straining of the housing and consequent departure from initial alignment is gradually being enforced by experience. I will briefly review the evidence and make two important additions.

(*a*) I refer to a report I received of a rigid gear which, after a successful trial, was found to have the teeth of one helix bearing over three-quarters of the length. This would give a maximum pressure about 2·67 times the designed mean. No doubt the alignment in the shop was made as perfect as possible. Thus there must always be a very large margin allowed for safety. This was a single-reduction gear.*

(*b*) Mr. W. R. L. Emmet, of the General Electric Company, states his experience that the safe load of gears at sea is less than one-quarter of that on land.

(*c*) Mr. Hadley F. Brown remarks that double-reduction gears must be large, and consequently it is difficult to maintain alignment in light and loaded draught, or when the vessel is rolling or pitching; that in one ship, when lightly loaded, the gear functioned well and quietly, but the noise increased when she was fully loaded, and the pinions wore out in less than one voyage; that some gears have to be renewed every four or six months, and it is proposed to take them out, while similar installations, on short voyages, last perfectly for years.

(*d*) The excessive wear, especially of the second-reduction pinion, noted in the article, ENGINEERING, vol. cix, page 599, is most easily accounted for by the warping of the ship—intense pressure being brought first on one part of the tooth face and then on another.†

(*e*) Mr. S. K. French, by a well-devised plan, measured the warping of the gear housing of S.S. Carenco on the voyage from Glasgow to Baltimore and back. The gear housing is 12 ft. 4 in. long by 8 ft. 6 in. wide. He observed the rise and fall of opposite corners relative to the middle. This gradually increased with the roughness of the sea till, in loaded condition of the ship, heavily rolling in a following sea, the waves being about 20 ft. high, the gauges showed a total relative movement of 1/20 in. One-fiftieth of this would very sensibly upset the distribution of pressure on the teeth.‡

(*f*) Mr. Robert Warriner remarks on the very minute warping allowable and directs that the gear housings should be so stiff that there will be no change of alignment when bolted in the ship; that the keelsons be made so substantial that they will contribute to this stiffness, and so built on to the ship's bottom that they will not be distorted by the considerable flexure of the ship produced by change of trim and action of the sea. (These conditions can be only partially realised.) He further remarks on the alterations of the ship's structure due to loading, trim and heavy weather; and that gears heavily loaded wear rapidly in heavy weather.

(*g*) Mr. Summers Hunter points out the great variations of condition in full-lined cargo boats, crossing the Atlantic, fully laden or in light trim.

(*h*) Messrs. Scott, of Greenock, have adopted the three-casing type of double-reduction gearing, the casings thus being reduced in size; for "the possibility of trouble arising from distortion of the gear due to the straining of the ship's structure is thereby reduced.§

(*i*) Mr. Robert Love remarks‖ "In the case of double-reduction gearing the seating of the gear-case must be well extended in the athwartship direction, and, as the structure of the gear-case is to a certain extent flexible, the accuracy of alignment necessary for this type of gear is likely to be impaired under bad weather conditions." And, further,¶ "I have examined gears cut by various British and American firms, and only in a few cases was there evidence of uniform bearing across the full face of the teeth." No doubt they were all carefully aligned in the shops.

(*j*) Mr. W. E. Sykes, whose whole remarks show that he has for many years given the most careful attention to the accurate manufacture of gearing, says: "While I agree that accuracy in manufacture and in alignment during erection is of prime importance, I think it desirable to point out that maintenance of accuracy is of equal importance. It is obviously of little use putting a ship in service with extremely accurate machinery if steps have not been taken to insure that the initial accuracy will be maintained. Much can be done in this direction by correct design of gear casing and seatings, but I am unable to express a firm opinion as to whether, in all types of general design and in the largest sizes, it is possible, notwithstanding the greatest care and skill, to ensure maintenance of alignment. I may say, however, that in some cases of trouble which I have carefully investigated, the failure has not been in the initial alignment but in misalignment due to deflection of gear cases."** Surely, light on the cause of the disaster is beginning to dawn, and we will soon have the clear day. It will then be wondered why the difficulty was not foreseen by all intelligent engineers, arising as it does avoided. Are we to conclude that they had not studied the design of floating-frame gears, which they have so consistently condemned; or that they stated to be impossible what had often been done; or did they simply forget and fail to think of this simple and effective device? I make this remark lest anyone might think my counter-criticism is stronger than is proper.

* See Trans. Inst. Naval Architects, vol. lv., Part I, page 50.
† See ENGINEERING, vol. cxi, page 369.
‡ See ENGINEERING, vol. cix, page 480.
§ See ENGINEERING, vol. cxii, page 143.
‖ See Trans. Inst. Naval Architects, vol. lxiii, page 83.
¶ See ENGINEERING, vol. cxi, page 370.
** See Trans. Inst. Engineers and Shipbuilders in Scotland, vol. lxi, page 365.
†† See Trans. Inst. Naval Architects, vol. lxii, page 154.

* See Trans. Inst. N.A., vol. lxiii, page 77, and ENGINEERING, vol. cxii, page 142.
† This is copied from the *Shipbuilding and Shipping Record* of June 30, 1921.
‡ See ENGINEERING, vol. cxi, page 369.
§ See Trans. Inst. N.A., vol. lxiii, page 92.
‖ For fuller information regarding these floating-frame gears, see ENGINEERING, vol. cxii, pages 180 and 660. On the latter page it is noted that the gears of U.S. Destroyer Satterlee reached K = 367 on her official trial, at 31,200 s.h.p. and 38·26 knots. She holds the official speed record of her class. In ENGINEERING, vol. cxi, page 490, Mr. Cook states that one successful example should be sufficient to justify the design and claims the five examples he has given in his paper as outstanding, pointing out that in others which cannot carry the same load some detrimental causes must be at work. I have given many examples of second-reduction pinions with much higher values of K than he shows, and now one of a single-reduction pinion still higher. I invite Sir Charles Parsons and his associates to run their gears at these loads. Should they not succeed there must, by Mr. Cook's reasoning with which I quite agree, be some detrimental causes at work. In ENGINEERING, vol. cxii, page 311, Captain Onyon, referring to the 17 ships with floating-frame gears, the success of which I had shown, very properly states that "it is hardly fair to make a statement showing successes unless this statement is accompanied by a list of failures." I was able to answer (page 660) that "there have been no failures due to the floating frame." If Messrs. Walker and Cook, in their Naval Architects paper had furnished a small list of typical failures of rigid double-reduction gears, and discussed them frankly, they would have added the greatest interest, and entirely removed the reproach that their paper was an appologia for double-reduction gearing.

* See ENGINEERING, vol. cxi, page 610.
† For (*b*), (*c*) and (*d*), see ENGINEERING, vol. cxi, page 641.
‡ See ENGINEERING, vol. cxii, page 179.
§ For (*f*), (*g*) and (*h*), see ENGINEERING, vol. cxii, pages 659 and 660.
‖ See Trans. Inst. Engineers and Shipbuilders in Scotland, vol. lxiv, pages 497 and 498.
¶ *Ibid.*, page 511.
** See Trans. Inst. N.A., vol. lxiii, page 88.

from the most elementary consideration of the elastic nature of the materials we are dealing with.

I conclude with another quotation from Messrs. Walker and Cook—not, as in their case, expressing an optimism which was not justified by their investigations, falling short as they did of discovering the fundamental cause; but led from the first by clear principle and confirmed by years of experience—"There is nothing to fear for the future success of double-reduction gearing."*

EXPLOSION OF A SUPERHEATER.

A PRELIMINARY inquiry, under the provisions of the Boiler Explosions Acts, 1882 and 1890, has been made by the Board of Trade with regard to the cause and circumstances of an explosion of a superheater which occurred on December 19, 1921, at the Aberthaw Portland Cement Works, owned by the Aberthaw and Bristol Channel Portland Cement Company, Limited, Aberthaw, Glamorgan. Two men were injured by the explosion, but subsequently recovered.

The superheater consisted of inlet and outlet steel headers of rectangular section, 8 ft. 6 in. long, 7½ in. square, and ⅜ in. thick, connected by 40 U-shaped solid-drawn steel tubes, 1½ in. in outside diameter and No. 9 L.S.G. in thickness. The headers were each fitted with ten 4½ in. by 4½ in. oval inspection holes closed by a dog and cap and secured by a close-ended nut screwed up on to a 1½-in. bolt. The tubes were expanded into the headers below these inspection holes in groups of four tubes and projected into the flue at the back of a Lancashire boiler, 8 ft. 6 in. in diameter and 30 ft. long. Steam was conveyed to and from the superheater by means of steam pipes, 6 in. in diameter, secured to flanges on the inlet and outlet headers by means of 12 bolts, ⅞ in. diameter. The mountings consisted of one 1½-in. diameter drain valve, one 3-in. diameter safety valve, one 1-in. diameter test cock, and one thermometer pocket. The superheater was fitted with sectional isolating dampers in front and swivel damper below for isolation purposes when steam was being raised in the boiler and no steam was passing through the tubes.

The superheater was made by Messrs. T. Sugden, Limited, 180, Fleet-street, London, and was installed at the Aberthaw Works in 1913. The tubes were made by the British Mannesmann Tube Company. Since that time five defective tubes had been blanked off by means of steel-tapered plugs driven into them. Two of these tubes had been blanked off on the day of the explosion; no record was kept of the dates when the other three tubes failed.

The superheater was insured with the Vulcan Boiler and General Insurance Company, Manchester, and was periodically inspected by one of their inspectors, the last examination being made on April 9, 1921, and the prescribed form under the Factory Act was issued by the insurance company, in which it was stated no repairs were required. It was also inspected by Mr. J. Hamilton, mechanical engineer to the Aberthaw and Bristol Channel Portland Cement Company, whenever the boiler was off range for cleaning purposes; his last inspection was made between October 18 and 31, 1921.

Mr. C. H. Thirkell, engineer surveyor to the Board of Trade, in his report states that the superheater from which the explosion occurred was one of five superheaters, and was known as No. 5. It was placed at the back of a Lancashire boiler working at a pressure of 180 lb. per square inch. About two years ago, after the superheater had been working for about six years, the first defective tube was located. A slight leak was discovered, whilst the boiler was under steam, by the sound of escaping steam. The defective tube was blanked off by means of tapered steel plugs driven into each end. Since then several of the tubes in the five superheaters had been found to be defective; each tube, on examination, was found to have failed owing to thinness in the leg attached to the outer header. At this time the engineer, Mr. Hamilton, suggested that a spare superheater should be obtained so that the superheaters could be removed one at a time, and the spare one put in place, whilst the one taken out was being re-tubed and tested hydraulically. A spare superheater was obtained but had not been installed, the number of defective tubes in any one superheater, in the opinion of the engineer, not justifying it.

On December 19, at 7.30 a.m., the fireman on duty heard steam escaping at the back of No. 5 boiler, and, on reporting the matter to Mr. Hamilton, received instructions to close this boiler down and draw the fires. The inlet and outlet valves to the superheater were closed and the fires drawn, the sectional isolating dampers were not put in and the swivel dampers were left half open. About 4 p.m. the defective tube had been blanked off and, on opening the outlet valve to allow steam from the other boilers to enter the superheater for the purpose of testing the inspection doors for steam tightness, steam was heard escaping into the flue from another tube. Two mechanics were instructed to locate this second defective tube and blank it off. The repair was completed about 7 o'clock, and the fireman was instructed to light up the fires in this boiler and raise steam to a pressure of 170 lb. per square inch. The fireman stated that he eased the inlet valve off the face and opened the drain on the superheater, and, about 8 o'clock, he connected this boiler up by closing the drain and opening the inlet and outlet valves. About 8.20 p.m. the explosion occurred and the two mechanics, who were standing on the superheater to examine the inspection doors for steam-tightness, were both injured by flue dust being blown into their eyes.

Mr. Thirkell, continuing his report, states that he examined the superheater after the explosion and found one of the tubes had fractured longitudinally for a length of 8 in., which allowed steam to escape into the boiler flues. The defective tube was found to be thinned by external smooth wasting, the metal at the part which failed being only $\frac{1}{16}$ in. thick. This thinning of the tube was due to erosion and overheating. When raising steam on these boilers, the superheater tubes were dry, and no steam was passed through them until a pressure was raised in the boiler and the inlet valve and drain opened. The isolating dampers were in sections and could not be said to be gastight, so the superheater tubes were subjected to a high temperature.

Concluding his report, Mr. Thirkell states that the explosion was due to the tube being too weak to withstand the pressure to which it was subjected.

Mr. Thomas Carlton, engineer surveyor-in-chief to the Board of Trade, in his "Observations," sums up as follows: "The gradual wasting of the tubes in superheaters of this kind is to be expected, and it appears necessary to remove a tube occasionally for examination after the apparatus has been in use for any lengthy period of time."

* See ENGINEERING, vol. cxii, page 167.

THE BRIQUETTING OF SWARF AND BORINGS.—We have received from Messrs. Hollings and Guest, Limited, of Thimble Mill-lane, Birmingham, particulars of their hydraulic presses for the briquetting of swarf, borings and other bulky scrap metal. The material is compressed into briquettes about 3 in. diameter by 4 in. long, weighing about 4 lb. each, according to the class of metal being treated. No binding materials are used, and the briquettes can be re-melted very much more conveniently and with less loss than swarf can be dealt with. Cast-iron borings can be treated, as well as metals of softer and more ductile kinds. The briquettes are stated to stand handling and dropping without crumbling or breakage.

GERMAN MILITARY AVIATION.—*Le Temps* has recently published a translation of an official German document entitled "Instruction on the Employment of Aviation to be used for Manœuvres, Regimental Exercises, and Drills on Tactics." By the Treaty of Versailles Germany is prohibited from keeping any air force whatever, but as this document shows she, nevertheless, is making complete plans for the future. Each army in active operations is to have assigned to it a combat unit with a strength of three or four squadrons. Each squadron comprises four escadrilles of 12 airplanes each. This represents a body of 150 to 200 airplanes which will have as its mission to take part in all the phases of the battle, both in aerial combats and in combat against the other arms. In an attack it will act with the assaulting troops, will precede the advanced troops, and will clear away enemy reserves, bombarding the centres of resistance. The pursuit unit will be especially charged with the aerial fighting. It comprises from four to six pursuit squadrons, each squadron comprising three escadrilles of 21 planes. Its object will be to hinder enemy reconnaissance and prevent the enemy fighting planes from taking part in the battle. It must enable its own reconnaissance airplanes to accomplish their mission. Pursuit planes should act in mass so as to be master of the air, at least during certain hours. They may be reinforced for certain missions by combat and bombing squadrons. The bombing aviation is less strong numerically than the combat and pursuit branches. It consists of from one to three squadrons, each formed of three escadrilles of 12 planes. It is to be used in bombing by day as well as by night.

RECONSTRUCTION WORK OF THE GREAT NORTHERN TELEGRAPH COMPANY.—On April 11, 1918, the Great Northern Telegraph Company's overland connection to the Far East was interrupted through revolutionary disturbances, and since then the company has been arduously endeavouring to re-establish this, their most important connection—an interesting and difficult piece of reconstruction. In order to impart what had been achieved so far some of the company's functionaries and a high Russian official set out from Petrograd in August, 1921, and they inspected the line throughout Siberia. The Russian lines were then found to be in good order, and the Russian automatic repetition stations having been re-equipped, the commission reached the town of Jochita in November. No connection had yet been established between the Russian lines and the company's East Asiatic system, and several difficulties confronted the commission. They could not get to Vladivostok through Siberia, and the cables to Japan are landed at this place. The most natural course would have been to attempt the re-establishment of the Kjochta-Peking connection which formerly was the company's main line between East Asia and Europe, but this line was, and is still, much damaged through the fighting in Mongolia, and the Governments in Urga and Peking could not agree about conditions for repairing the line. Another solution, therefore, had to be found. The Russian Governments having given the company permission to dispose of the wires between Irkutsk and Vladivostok, the line was carried in a cable across the Amur River to the Chinese town of Helempo, and from Helempo a line proceeds to Peking by way of Charbin and Mukden, which line the Chinese Government has transferred to the Great Northern Telegraph Company; in consequence a Danish staff of functionaries proceeded to Charbin with the necessary material, and they are now working the station. The distance between Petrograd and Peking is about 6,000 miles over which distance there are about 10 re-telegraphing stations. From Peking the company's station telegraphs direct to the Irkutsk station, which again telegraphs direct to the Petrograd station and this one again to the Gothenburg station, which becomes the central receiving and despatching station for the whole of the East Asiatic traffic.

CATALOGUES.

Testing Apparatus.—Messrs. Bruntons, Musselburgh, Scotland, send a copy of the second edition of their publication describing the testing plant at their wire mills.

Electric Water Heater.—A small water heater suitable for domestic use is described in a catalogue issued by Messrs. E. S. Russell and Co., 243, Great College-street, London, N.W. 1.

Water-Tube Boilers.—A catalogue describing their water-tube boiler and containing some remarks on the need for critical examination of recent practice, has reached us from Messrs. Clayton and Shuttleworth, Limited, Lincoln.

Case-hardening.—The Cassel Cyanide Company, Limited, 19, St. Vincent-place, Glasgow, send a copy of an interesting booklet describing their case-hardening process, which is suitable for rapidly forming a casing up to $\frac{1}{32}$ in. in thickness.

Steel Castings.—The Kryn and Lahy Metal Works, Limited, Letchworth, Herts., send a catalogue illustrating many examples of light and heavy steel castings produced at their "Garden City" works, where they also have extensive machine shops.

Stone-Working Machines.—A catalogue of stone-working machinery received from the Anderson-Grice Company, Limited, Carnoustie, Scotland and Queen Anne Chambers, Tothill-street, London, S.W. 1, deals with circular saws, reciprocating frame saws, and wire saws; several moulding and polishing machines and a neatly designed floor-polishing machine with hinged rotating head driven by an engine or motor on a truck. The circular saws have diamond or carborundum cutters, the former being the more economical where the work is sufficiently heavy.

Hydraulic Machines.—A catalogue of hydraulic machine tools and oil mill machinery made by Messrs. Musgrave Brothers, 11, East-street, Leeds, covers a much wider range than these headings suggest. In addition to the pumps, accumulators, valves and general fittings suitable for hydraulic power there are forging, flanging, punching, bending, shearing, riveting and other heavy metal working machines, and an extensive series of hydraulic presses, cranes, &c., such as are used in many different industries. The oil mill plant includes complete outfits. A charge of 10*s.* is made for this catalogue which contains 250 pages.

Wood-Sawing Machinery.—Three catalogues of machines for sawing logs into boards comes from Mr. John T. Pickles, Hebden Bridge, Yorkshire. A band saw for cutting off one board at a time is shown in several sizes, the largest one capable of handling logs up to 42 in. diam. In these machines the saw cuts vertically and the logs are carried along automatically. Single blade straight reciprocating sawing machines and similar machines with multiple-spaced saws are also dealt with. The aim of the designs is to give a choice between a multiple cutting machine requiring considerable driving power and a machine for similar work operating in single cuts, and thus requiring proportionately less power and a lower capital expenditure.

Road Rollers.—The nominal weights (empty) of road rollers is 6 tons, 8 tons, 10 tons, 12 tons, 14 tons and 16 tons, but the heaviest is not generally used. The engines are either single cylinder working at 150 lb. per square inch pressure or compound working at 180 lb. per square inch. The boiler-making is of the highest quality, and various fittings are often added such as water sprayers, scarifiers, winding drums, and liquid fuel burners. Occasionally enlarged fire boxes to burn wood or inferior fuel, which may be obtained locally, are fitted. This, and much more, may be learned from the road roller catalogue recently issued by Messrs. Marshall, Sons and Co., Limited, Gainsborough, who for many years past have supplied large numbers of their machines for use at home and overseas.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—The desirability of standardisation in connection with chemical fire extinguishers was brought to the notice of the association by the manufacturers of liquid chemical fire extinguishers after correspondence with the various Government Departments. A conference of all interests concerned was convened by the association, and as a result of this conference a Sectional Committee was formed to undertake the work. One of the ruling principles of the association is that no standards are prepared which would in any way interfere with progress and inventive design, and whilst it was generally recognised that standard methods of operation and interchangeability of parts of chemical fire extinguishers would be of material advantage to Government Departments and other large users, the trade felt that it would not at present be to the best interests of the industries concerned to carry the standardisation to this extent. The scope of the specification (No. 138, 1922) has, therefore, been confined mainly to materials and constructional strength. Every extinguisher purporting to be made in accordance with this specification must, when completed, withstand an internal hydraulic pressure of 300 lb. per square inch. The pressure generated in the machine under working conditions must not exceed 100 lb. per square inch and at least 95 per cent. of the fluid in the vessel must be automatically discharged. General requirements are laid down for the cap joint, cage, bottles, charge nozzle, &c., which, while essential to the efficiency of the machine, impose no restrictions on the design.